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1941

Fifth Annual Report

U. S. Regional Pasture Research Laboratory

State College, Pennsylvania

Division of Forage Crops and Diseases

Bureau of Plant Industry

and

The Agricultural Experiment Stations

of the

Northeastern States

Cooperating

- - - -

Forty copies of this Report were made and distributed as follows:

Three copies to the Division of Forage Crops and Diseases; one copy to each of the twelve Directors of the cooperating State Agricultural Experiment Stations in the Northeastern United States; one copy to the President of the Pennsylvania State College; one copy to the Conservator of the Northeastern Region of the Soil Conservation Service, Upper Darby, Pa.; one copy to the Director of each of the following State Agricultural Experiment Stations - Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Ohio, Tennessee, Virginia, and Wisconsin; one copy to the Dominion Agrostologist, Ottawa, Canada; one copy to the Dean of Agriculture, Saskatoon, Saskatchewan, Canada; one copy to the Director of the Welsh Plant Breeding Station, Aberystwyth, Wales; one copy to the Director of the Swedish Seed Growers Association, Svalof, Sweden; one copy to the Director of the Waite Agricultural Research Institute, Adelaide, Australia; and the remaining four copies to the U. S. Regional Pasture Research Laboratory.

THE LABORATORY STAFF

R. J. Garber. Director

Tracy J. Trachsel Secretary

Project Leaders

J. T. Sullivan. Physiologist

W. M. Myers Geneticist

S. S. Atwood. Associate Agronomist

R. R. Robinson. Associate Agronomist

V. G. Sprague Associate Agronomist

K. W. Kreitlow. Agent

Technical Assistants

Helen D. Hill Cytogenetics

Martha Jayne. Biochemistry

Greenhouse and Nursery Foreman

Ralph W. Kerns

COLLABORATORS

B. A. Brown, Connecticut C. B. Bender, New Jersey

G. L. Schuster, Delaware C. E. F. Guterman, New York

D. S. Fink, Maine S. I. Bechdel, Pennsylvania

W. B. Kemp, Maryland B. E. Gilbert, Rhode Island

W. G. Colby, Massachusetts G. P. Burns, Vermont

F. S. Prince, New Hampshire G. G. Pohlman, West Virginia

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This annual report of activity at the Pasture Laboratory, as well as of that at the state stations with which the Laboratory cooperates, is a progress report and as such may contain statements which may or may not be verified by subsequent experiments. The fact that any statement has been made herein does not necessarily constitute publication. For this reason citation to particular statements in the Report should not be published unless permission has been previously granted by the Laboratory or the state station concerned.

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THE UNITED STATES REGIONAL PASTURE RESEARCH LABORATORY

For the Calendar Year,

1941.

INTRODUCTION

Early in December the Nation was catapulted into war, and with war came greater responsibilities for agriculture. Not only are we faced with the necessity of producing larger quantities of certain concentrated foods, but we must also find and increase plant materials that may be substituted for those no longer available in sufficient quantity. Increased production of dairy products, particularly the more concentrated forms, is urgently needed. Seed stocks of some pasture plants must be increased to meet domestic demands. Here, then, are two direct needs among others that might be mentioned that have grown out of the present national emergency and are closely related to pasture research.

This is not the place to discuss to what extent our present pasture research program should be modified to meet present exigencies. It may not be amiss, however, to point out that, insofar as our research at the Laboratory meets the requirement of being fundamental and of being of regional interest, it should serve equally well in solving practical pasture problems uppermost at the moment as well as those likely to confront us later. This does not mean that the plans drawn up and the specific objectives set out when the present research was undertaken are not subject to modification. On the contrary, an almost continuous reevaluation and adjustment of our pasture research activities are necessary if they are going to serve effectively the Region as a whole.

Another aspect of the present research program may be mentioned. The Laboratory, in cooperation with some of the state experiment stations, is actively engaged in breeding better strains of pasture plants for the Northeastern Region. This work was initiated so recently that new strains are not yet developed and fully evaluated. Recognizing this fact, would it be well to increase some of the breeding stocks now on hand, even though their adaptability is still somewhat uncertain, to take the place of ordinary commercial seed and seed of strains no longer available?

The plan followed in writing the present Annual Report parallels closely the one followed last year. Progress on cooperative projects between state stations and the Laboratory is again reported in a separate section. The appendix contains progress reports of pasture and grass silage investigations under way at the twelve Northeastern Agricultural Experiment Stations. A subject matter index covering these latter reports is included.

The description of activity at the Laboratory is grouped around cytogenetics and breeding, physiology and plant composition, and pathology. A rather detailed table of contents and list of publications issued during the year complete this part of the Report. The phases of research completed and published or in the process of publication during the five and one-half years the Laboratory has been in existence number thirty-one.

Perhaps the outstanding single accomplishment of the Laboratory during the calendar year of 1941 was the completion of the temperature-control chambers and the initiation of experiments for which the chambers were designed. Illustrations showing the chambers and some of the plant responses obtained in them are shown. (Figs. 1 and 2).

CHANGES IN PERSONNEL

Dr. K. W. Kreitlow, plant pathologist, was appointed to fill the vacancy created by the resignation of Dr. S.J.P. Chilton. Dr. Kreitlow received his training and experience at Minnesota University, Louisiana State University, and the Rockefeller Institute.

Mr. Armand G. Morin, technical assistant in plant physiology and chemistry, withdrew to join the armed forces. Miss Martha Jayne was appointed to take his place.

Miss Tracy J. Trachsel was appointed secretary to succeed Mrs. Alice M. Atkinson.

ADDITIONS TO EQUIPMENT

The construction of four environmental control chambers started in 1940 (1940 Annual Report, page 8) has been completed. These chambers are so designed that climates ranging from hot humid to cool dry conditions can be simulated within the range from 20° F. to 120° F. with relative humidities of 20% to saturation at all



Fig. 1. Environmental Control Chambers

- A. Front of the four chambers. Upper doors are double to permit observation through glass inner door without allowing the outside air to enter.
- B. The control valves, air ducts, and brine pumps at the rear of the chambers.
- C. Two of the four time-temperature recorder controllers; note the control cans in the left doors which, in this instance, are cut for high day temperatures with low humidities and low night temperatures with high humidities.
- D. One chamber with inner door open, showing pots immersed in brine. Brine temperature controlled independently of air temperature. Note fluorescent lamps overhead.

except the lower temperatures. Soil temperatures are controlled independently of air temperatures. All conditions are controlled by time clocks and metal cams so that alternating temperatures and humidities of any duration or fluctuation as well as constant conditions may be maintained. Light is supplied by 48-inch fluorescent lamps above the chambers which provide an intensity of approximately 550 foot-candles four feet below and perpendicular to the lamps. Flat white paint on the four inside walls of the chambers reflect the light and provides an additional intensity of approximately 350 foot-candles from each wall. At the present time one-half of the lamps are "daylight" and the other half "white." Preliminary work indicated that the spectrum of the "daylight" lamps was slightly deficient in the red region and this could be increased by the use of "white" lamps. The lamps are controlled by time clocks so that any daylength desired can be obtained. This equipment should prove particularly valuable in studying plant responses to temperature, light, and humidity.

A research microscope was purchased to facilitate chromosome studies.

With a plant nursery of approximately 25 acres to care for, it seemed desirable to purchase a complete set of farm implements rather than depend on hired services. During the year a farm tractor together with adequate implements were obtained and a small shed erected in which to store them when not in use.

The problem of storing sufficient soil for work in the greenhouse during winter was mitigated by erecting a soil bin of brick and concrete and connecting it with the headhouse.

ACTIVITIES RELATING TO COORDINATION OF RESEARCH

Under this heading are grouped brief discussions of activities that relate directly to attaining the general objective, pasture research on a regional basis in the Northeastern States.

Meeting of Collaborators

The fifth annual meeting of the collaborators was held at State College, Pa., July 8, and 9, 1941. The program and discussions hinged around the general topic, "Effect of Environmental Factors upon Growth and Development of Pasture Plants." In all, 44 persons, including

representatives of each of the cooperating agencies and a number of plant physiologists and agronomists invited by the collaborators, attended the meeting.

Previous to the meeting, project outlines were prepared and sent to the collaborators as suggested bases for discussions. The topics which follow are indicative of the scope of the subject matter covered:

1. Survey of the environments to which pasture plants in the Northeast are naturally subjected.
2. Effect of climate on the growth of pasture plants.
3. Life history studies using environmental-control chambers to study seedling growth and development, vegetative growth, seed production, and chemical composition.
4. Effect of temperature and photoperiod on seed germination and seedling establishment.

A committee headed by Dr. B. E. Gilbert was appointed to prepare a résumé of the discussions and make recommendations. The committee approved, in general, the projects proposed and, in addition, made a number of specific suggestions. The committee also indicated what phases of the general problem seemed most important, and, therefore, should first be investigated. A lively discussion followed and, although unanimity of opinion was not reached, the discussion did serve to further clarify ideas. The committee recommended that a regional committee of three persons with the chairman a member of the Laboratory staff be appointed by the Director of the Laboratory after consultation with the twelve agricultural experiment station directors in the Northeastern States. This committee was to be charged with the responsibility of (a) determining the climatological data of value in pasture research, (b) tabulating and analyzing existing data, and (c) suggesting type of data to be collected in the future. The committee report with some alterations was accepted shortly before adjournment.

At a special evening session a brief account was given of research activity at the Laboratory. Project leaders were present to answer questions and explain plans for further development.

After adjournment of the general meeting, the collaborators assembled for a short meeting. A committee

consisting of Messrs. Guterman, Brown, and Bondar was appointed to make suggestions for a program for the next annual meeting.

A rather detailed report of the collaborators' meeting was mimeographed and mailed to each participant in the meeting.

Regional Committee on Climatology

The special regional committee appointed in accordance with the collaborators' recommendations consists of Dr. V. G. Sprague, of the Laboratory staff, chairman; Professor B. A. Brown, research agronomist at the University of Connecticut; and Professor E. R. Biel, meteorologist of the New Jersey Agricultural College. The committee held a meeting at New Brunswick, N. J., and prepared tentative proposals to consider pasture-weather relations in the Northeastern States. These proposals were mimeographed and a copy sent to each collaborator just before the end of the year. The committee suggested that before attempting an analysis and summary of weather records in the Northeastern States, some regional experiments be carried on to correlate climatic data with the growth of plants in order to ascertain what part of the voluminous weather data is most likely to be of direct interest in an environmental study of pasture plants.

Regional Grassland Conference

A regional grassland conference was held in connection with the summer meeting of the Northeastern Section of the American Society of Agronomy at Durham, N. H., June 25, 26, and 27. One full day was devoted to the presentation of papers concerned with various phases of grassland agriculture in the Northeastern Region. Field trips were made during the remaining two days. Professor Ford S. Prince, agronomist of the New Hampshire Agricultural Experiment Station, and the sectional officers of the Society arranged for the program.

Miscellany

During the year, another cooperative project was developed, bringing the total now active to nine. Progress on these projects is reported in the next section.

As in previous years, a number of persons interested in some phase of pasture research called at the Laboratory to inspect work under way. All but one of the twelve State

Agricultural Experiment Stations with which the Laboratory is cooperating was visited one or more times during the year by some member of the Laboratory staff.

Several inspection trips of the Laboratory and nursery were conducted for special groups that visited Pennsylvania State College during the period covered by this Report.

COOPERATIVE RESEARCH BETWEEN STATE STATIONS AND THE LABORATORY

AGROSTIS TENUIS BREEDING (WITH RHODE ISLAND)

Title: Breeding Rhode Island Colonial Bent Grass for Pasture Types.

Leaders: For the Rhode Island Agricultural Experiment Station - T. E. Odland and J. A. DeFrance.
For the Pasture Research Laboratory - W. M. Myers

A total of 537 progenies from head selections made in 1940 were grown in the greenhouse during the winter of 1940-41. From these; 458 were selected for growing in a field nursery with 1 to 10 plants from each. These were transplanted to the field during May. In addition, five clones from each of 227 inbred selections from a previously established nursery were transplanted to this new nursery. Notes on vigor, leafiness, growth habit, disease susceptibility, and other characteristics were taken on all selections and clones during the growing season. Special attention was given to any characteristics that would seem to make a selection a promising pasture type.

Cross-pollinated seed was obtained from plants that showed the most promise for future use. A large number of heads were bagged for selfed seed but this procedure met with little success. This species is apparently very largely self-sterile. The seed from the open-pollinated plants will be used for increase and further selection.

In October, 207 clonal selections were made from the nursery and set out in small plats each 3 x 6 feet. Each plat was planted with 18 clones from a single plant in the nursery. These clones will be allowed to form a solid turf and then kept clipped in order to study their behavior under conditions similar to pasture.

A special study is being made of the extent of inter-crossing among bent grass species.

ANATOMY OF GRASS SEEDLINGS (WITH RHODE ISLAND)

Title: The anatomy of grass seedlings as influenced by environmental factors under controlled conditions.

Leaders: For the Rhode Island Agricultural Experiment Station - Irene H. Stuckey.
For the Pasture Research Laboratory - V. G. Sprague.

Work on this project was begun just before the end of the calendar year of 1941.

CHEMICAL COMPOSITION OF PASTURE GRASSES (WITH NEW HAMPSHIRE)

Title: The Chemical Composition of Pasture Grasses.

Leaders: For the New Hampshire Agricultural Experiment Station - T. G. Phillips and T. O. Smith.
For the Pasture Research Laboratory - J. T. Sullivan.

In the analysis of plant material, crude fiber and, more recently, lignin and cellulose, have been determined directly. Other less resistant carbohydrates are usually estimated by difference. It is the objective in this study to obtain information about the more labile forms by positive methods.

During the past year, work has progressed on the development of quantitative methods for determining mixtures of sugars and on the quantitative measurement of sugars obtained by hydrolysis of polysaccharides.

Improvement has been noted in the quantitative measurement of glucose and fructose in the presence of each other.

A convenient method has been developed for adapting baker's yeast to the fermentation of galactose. In attempting to use this yeast in the determination of galactose in the presence of pentoses, it was found that the adapting process changes the permeability of the yeast to arabinose,

thus introducing an appreciable error. Methods for overcoming this difficulty are being studied.

Alcohol-insoluble portions of grass tissue have been subjected singly and successively to the action of mild acids, takadiastase and strong acids, with the following results:

Mild acid hydrolysis combined with iodine treatment makes possible a good estimate of the fructosan present.

Takadiastase sets free both fermentable and non-fermentable aldoses, the former, probably glucose only, exceeding the latter in the bluegrasses and ryegrasses.

Large amounts of sugars are set free by strong acid hydrolysis. In timothy, these account for about 20% of the insoluble solids of the grass and 75% of them are non-fermentable.

DACTYLIS GLOMERATA, LOLIUM PERENNE, AND FESTUCA SPP.

BREEDING

(WITH MARYLAND)

AND

DIVISION OF FORAGE CROPS & DISEASES)

Title: Selection, Inbreeding, and Crossing to Obtain Orchard Grass (Dactylis glomerata), Ryegrass (Lolium perenne, and L. Multiflorum), and Fescue (Festuca spp.) Strains Adapted Particularly for Pastures in Maryland.

Leaders: For the Maryland Agricultural Experiment Station - W. B. Kemp.

For the Division of Forage Crops & Diseases, Bureau of Plant Industry, U. S. Department of Agriculture - P. R. Henson.

For the Pasture Research Laboratory - W. M. Myers.

Orchard Grass. The source nursery of over 4,000 spaced plants (1940 Annual Report, pages 12-13) was continued and preliminary notes were recorded on winter injury, early spring growth, date of heading, and other characters. An additional nursery of about 500 spaced plants from four seed collections was established. Sod plugs of orchard grass were collected from old pastures in central and southwestern Pennsylvania, and these will be planted in the spring of 1942 in the field.

Rather extensive inbreeding programs are being continued at Beltsville, Md., and State College, Pa. There are

included plants of the first, second, and third generations of inbreeding by selfing and of the first generation of inbreeding by sib-mating.

Seed was harvested from the isolation plots described previously (1940 Annual Report, page 13) and these strains have been included in the Grass Nursery. In addition, isolation blocks have been planted from seed of each strain for the production of an advanced generation for testing.

In addition to the cooperative breeding activities, studies of fundamental problems relating to breeding are being carried out by each agency.

Perennial Ryegrass. In the previous year individual plants from seed of perennial ryegrass either from wild local stocks collected at different places in Maryland or from commercial strains were scored for growth habit and for resistance to Helminthosporium and to leaf rust. Marked differences in resistance to these diseases were observed. All plants were destroyed except those which scored high on disease resistance. A number of opportunities for controlled crossing among these resistant plants were provided by covering heads of different plants in one bag. Enforced self-fertilization was attempted with other bags. However, very little seed was obtained from self-pollination.

Seed produced under the crossing bags was planted in August and from observation of the surviving plants an effort will be made to compare the combining abilities of different parents for vigor, disease resistance, and plant type.

The parent plants have been retained for vegetative increase for crossing of those which show greatest promise.

Fescues. Seed and plant material of meadow fescue were collected from 23 different sources, largely old pastures and roadsides in central Pennsylvania. A nursery of about 2,000 spaced plants has been established from this material. Chromosome numbers were determined from one plant obtained from each panicle which was collected. All plants were diploid ($2n = 14$) with the exception of two which may be trisomic.

Local plants of tall fescue, and of red fescue with decidedly creeping growth habit, have been selected from nurseries grown previously. Seed has been saved from these plants for comparison of the appearance and growth characteristics of their progenies.

OVER-LIMING INJURY (WITH CONNECTICUT)

Title: A Study of the Causes of Over-liming Injury to Pasture Species.

Leaders: For the Connecticut (Storrs) Agricultural Experiment Station - B. A. Brown.
For the Pasture Research Laboratory - R. R. Robinson and V. G. Sprague.

Hydrated lime at the rate of four tons per acre produced over-liming injury in pots of both Charlton fine sandy loam and Merrimac fine sandy loam. The injurious effect gradually disappeared, and after about four months was no longer noticeable with alfalfa on Charlton and Merrimac soils or with Ladino clover on Charlton soil. With soybeans, however, the injury persisted during the second year.

Temporary over-liming injury to alfalfa and Ladino clover was not prevented by borax (10 pounds per acre), zinc sulfate (10 pounds per acre), manganous sulfate (30 pounds per acre), or copper sulfate (30 pounds per acre). Injury to soybeans was not reduced by borax at 10 and 20 pounds per acre before planting or by a total of 50 pounds per acre at intervals during the season. With mangels, however, borax was very effective in preventing over-liming injury.

The fact that soybeans on over-limed soil exhibited definite symptoms of boron toxicity after borax in solution had been added in mid-season, demonstrated that the boron had not been rendered unavailable to the plant by the soil. This was also demonstrated in the laboratory by finding about the same amounts of boron in the water leachates of limed and unlimed, borax-treated soil.

POA PRATENSIS BREEDING (WITH PENNSYLVANIA)

Title: Breeding Kentucky Bluegrass for Improved Pasture Types.

Leaders: For the Pennsylvania Agricultural Experiment Station - H. B. Musser and S. I. Bechdel.
For the Pasture Research Laboratory - W. M. Myers.

During the past season, work on breeding Kentucky bluegrass has fallen into five main categories, namely:

1. Collection of source material for further selection.
2. Selection of individual plants.
3. Progeny uniformity tests of previously selected plants.
4. Seed multiplication of uniform selections.
5. Preliminary field plot tests of new selections.

Collection of Source Material. The extreme severity of the epidemics of several diseases on Kentucky bluegrass during the late summer of 1941 seemed to provide an unusual opportunity for searching in old pastures for disease-resistant types. Sod plugs which seemed to be relatively disease-free were isolated from 44 pastures in central and southwestern Pennsylvania and northwestern West Virginia.

Selection of Individual Plants. In addition to the selections used in the progeny tests reported under "Method of Reproduction in *Poa pratensis*," (see section on Research at Laboratory), individual plant selections have been made from the following sources:

1. Thirty-six plants from 14 different first-generation progeny tests.
2. Seventy-eight plants from sod plugs isolated from old pastures, mostly in Pennsylvania.
3. Thirty-two plants from introduced strains.
4. Twenty-four plants from commercial seed.

Progeny tests of these plants have been established.

Progeny Uniformity Tests. Progeny uniformity tests are made with 20-plant progenies of individual parents. During the past season, uniformity observations were made on 61 progenies. Seed was harvested from 39 progenies which appeared to be uniform. However, this does not represent the ratio of uniform to variable progenies since some of the progenies were repeat tests and seed was not harvested from them.

A new series of progeny uniformity tests of 145 individual parent plants selected in 1940 was started this year. Plant mortality in the field nursery was high because of the drought and it will be necessary to replant a number of these progenies next year.

Seed Multiplication. Bulk seed was harvested from row plantings of 24 strains. Rows of each strain consisted of 100 to 200 plants set out individually to guard against contamination from volunteer plants.

Field Plot Tests. In the spring of 1941 preliminary field plot trials of 25 strains of Kentucky bluegrass were planted for tests of turf establishment, disease incidence under clipped conditions, and other adaptation factors. The plots in this test are 5 feet x 10 feet in size and are replicated six times in randomized blocks. Three check plots were seeded in each block with a blend of equal parts of seed of four individual strains. These check plots are for use as standards for observational records. Three of the six block replications were seeded with white clover, but owing to the extremely droughty conditions prevailing during the early part of the season, the clover failed to establish itself.

A preliminary clipping with an ordinary bar mower at about a 3-inch height was made in mid-June to clean up summer weeds. Two additional clippings were made with a lawn mower in late July and mid-August to a height of approximately 2-1/2 inches. Because of the dry season, no additional clippings were necessary. No clipping weight records were kept during this first season because of variability in rate of stand establishment, apparently due largely to the droughty conditions.

Records of turf density and per cent ground cover, disease incidence (Helminthosporium vagans), and fall cold tolerance were secured during the growing season. The turf density and ground cover records were secured during the fourth week in June by making quadruplicate counts on each plot with a point quadrat. Disease infection percentages were obtained September 19 to 22 from counts of all clean and infected leaves from triplicate 12 square inch areas on each plot of a single block. Fall cold tolerance observations were made November 29. Observations were on the basis of color retention and were in five percentage groups as follows: -0-20; 21-40; 41-60; 61-80; 81-100.

POA PRATENSIS AND TRIFOLIUM REPENS BREEDING
(WITH WEST VIRGINIA)

Title: Breeding and Improvement of Pasture Grasses and Legumes.

Leaders: For the West Virginia Agricultural Experiment Station - E. J. Wellhausen and R. O. Weibel.
For the Pasture Research Laboratory - S. S. Atwood (White Clover) and W. M. Myers (Kentucky Bluegrass)

The 2,500 individually spaced bluegrass plants planted late in the fall of 1940 were allowed to establish themselves in 1941. No notes were taken. The nursery was cultivated twice and mowed once. Seed was taken from 275 individual plants in June 1941. Seed from each plant was germinated and approximately 40 progenies of each transplanted to flats. These did not establish themselves well enough to warrant transplanting to the field for winter, and, consequently, are being carried over in flats.

An additional 1,100 individual plants were added to the bluegrass nursery last summer, bringing the total individually spaced plants to approximately 3,600.

Twenty-six clones of bluegrass that were selected at random from a poor pasture (mostly broomsedge and poverty grass) and 28 clones that were selected at random from a good pasture were brought into the greenhouse for the purpose of studying their response to various fertilizer treatments. A good epidemic of mildew was obtained and the clones classified according to resistance and susceptibility as follows:

	Susceptible	Moderately Susceptible	Resistant
Clones from poor pasture	8	10	8
Clones from good pasture	2	3	23

By far the majority of clones from the poor pasture were susceptible to mildew. Whether they will also be more susceptible to certain other diseases remains to be seen.

Approximately 1,000 individually spaced white clover plants now have been established. The first notes on these will be taken in 1942.

SNOW MOLD IN PASTURE AND FINE TURF GRASSES (WITH PENNSYLVANIA)

Title: Snow Mold in Pasture and Fine Turf Grasses.

Leaders: For the Pennsylvania Agricultural Experiment Station - C. C. Wernham.

For the Pasture Research Laboratory - K. W. Kreitlow.

Continuation of the work reported in 1941 developed several lines of endeavor. Most range work now in progress may aid in interpreting some of the data previously gathered.

Evidence accumulated during the past year indicated possibilities of geographic races or different species from widely separated localities. A number of orchard grass selections were inoculated in field plots with three representative cultures of the Typhula organism. Data from these inoculations should contribute toward determining the importance of this organism as a factor in winter-injured forage grasses.

TRIFOLIUM REPENS BREEDING (WITH NEW JERSEY)

Title: Breeding white clover for pastures.

Leaders: For the New Jersey Agricultural Experiment Station - H. B. Sprague.

For the Pasture Research Laboratory - S. S. Atwood.

Progeny Test of Diallel Crossing System. The material and methods used in the diallel crossing program were described previously (1940 Annual Report, page 15). Because of the large number of progeny to be tested, only part of the total number was started in 1940. Another block was started in the field June 10, 1941, in a manner similar to that used in 1940. Although there are 79 hybrids replicated three or more times, there are still 111 crosses replicated less than three times. It is hoped that these may be completed in 1942.

During the summer of 1941, notes were taken on both the 1940 and 1941 plantings. In the former, observations were made on density of occupation, and a tally was made of all rows outstanding in vigor and uniformity. In the 1941 planting, general vigor was recorded, similar to notes taken in 1940 on that year's planting.

From the tally of outstanding rows in the 1940 planting, a table was prepared showing the number of crosses in which each parent appeared in relation to the number of outstanding crosses in which each parent appeared. This may be regarded as a preliminary evaluation of the parent plants on the basis of progeny behavior, although final conclusions will not be drawn until the test is completed. From this preliminary evaluation four plants were judged superior. These strains are 3-20 (6-3), 36-23 (6-9), 36-38 (6-10), and Missouri 33 (6-16).

Continuous Selection System Without Diallel Crossing. Six clones from each of six superior giant type white clover plants were planted in Latin square formation in a block

isolated from other white clover. Seed was collected from these plants in the summer of 1941 and germinated with the intention of starting a progeny test. Growth of the seedlings in the greenhouse, however, was so greatly restricted that the progeny test could not be started. By making crosses between the parent plants in the greenhouse during the winter of 1941-42, it is hoped that enough seed may be obtained to carry out the plans next summer. The progeny will be tested in a grass association as well as alone.

Drought Resistance Study. The object of this study is to obtain a method for evaluating white clover plants with regard to their internal drought resistance, that is, resistance to desiccation, as distinguished from differences in root extent or ability to obtain moisture from soil. The plants used are two sets of F_1 progenies from the progeny test described in the first section above. Besides the 15 individual plants in each progeny group, four of the parent plants (used in the diallel crossing) are included. Each individual plant is replicated three times in the experiment.

The first test was unsuccessful, because the desiccation proved to be so severe that all cultures were killed.

A second test is underway during the winter of 1941-42. The plants are being grown in the greenhouse in pots containing equal quantities of soil. When the soil is well-filled with roots, the plants will be wilted. All of the plants will be wilted within one-half day of each other, if possible. After several days of this severe "drought", water will again be added to the pots and the differential recovery noted. After recovery, the wilting will be repeated several times until all of the plants have succumbed.

RESEARCH AT THE LABORATORY

CYTOGENETICS AND BREEDING OF GRASSES

Fertility Studies in Dactylis glomerata, Lolium perenne, and Phleum pratense

Emasculation with Hot Water. Studies reported (1940 Annual Report, page 17) were continued with timothy and orchard grass and similar results were obtained except that 48° C. was lethal to the orchard grass. There is apparently a very narrow range of critical temperature under the conditions used in these investigations.

Variation and Inheritance of Ability to Set Seed Under Bag. Determination of seed-set has been completed for the experiments previously described (1940 Annual Report, page 17), and a more complete summary of the results is possible.

Data on number of seeds per panicle set under bag were obtained for 51 clones during three years, 1938, 1939, and 1940. The 3-year average for these clones ranged from 1.3 to 191.3 seeds per panicle. Replicated data were collected during 1939 and 1940 and the data were reduced by the analysis of variance. To overcome the difficulty imposed by such heterogeneous material, the 51 clones were separated on the basis of their mean seed-set into five groups as follows: 1 to 10, 10 to 25, 25 to 50, 50 to 100, and 100 to 200 seeds per panicle. The differences between years were statistically significant in two of the groups and the interaction of years x clones was significant in two groups.

The most striking feature of the results was the extremely high mean square for error. In each of the groups, the standard error of a single determination approached the magnitude of the mean of that group. A knowledge of the components contributing to that variance is of considerable importance. The data were collected in 1940 in a manner permitting the separation of the components of the error variance into variance between bags on the same plant, variance between plants in the same row, and variation between clonal rows. This analysis for the 1 to 10 group of clones is shown in table 1.

Table 1. Analysis of variance of number of seeds per panicle set in 1940 on plants of parental clones, the mean seed-set of which ranged from 0 to 10.

Variation due to	:D/F :	Mean square
Replications	: 2 :	115.5046
Clones	: 11 :	123.0135
Error	: 22 :	44.4693
Within rows of clones	: 36 :	21.4476
Within plants	: 144 :	13.1227

The error variance consists of three components, i.e., variation between clonal rows, variation within clonal rows (between plants), and variation within plants (between bags). The relationship of these components is expressed by the formula -

$$r = N_b(N_p \cdot N_r \cdot K - N_p \cdot p - q)$$

where

K = variance of the mean for error

p = estimated true variance between clonal rows

q = estimated true variance between plants within rows

r = variance between bags on a plant

N_r = number of replications

N_p = number of plants in each row

N_b = number of bags on each plant

Calculations made using this formula indicated that any appreciable reduction in error variance could be accomplished only by increased replication.

In another experiment the effects of protecting the culms by wrapping them with cotton at the base of the bag, of number of panicles in the bag, and of order of maturity of the panicles on the plant were investigated. Three replications of four clones were used and a "split plot" type of design was employed. Protection of the culms with cotton did not affect the seed-set. The average number of seed per panicle with 1, 2, 4, and 8 panicles per bag was 60, 63, 54, and 40, respectively. The average for 8 panicles was significantly lower than any other. The first group of panicles to emerge on the plants averaged 69 seed per panicle as compared with 39 for those panicles emerging about one week later. The difference is statistically significant.

In 1940, data were collected on open-pollinated seed-set in addition to seed-set under bag and the latter was expressed as percentage of the former. The clones ranged from 0.8 to 51.1%. The differences among clones were very highly significant statistically.

Data were obtained on number of seed per panicle set under bag on first-inbred-generation progenies of 46 clones. The correlation coefficient of mean seed-set of the parental clones with the average of their inbred progenies was 0.62, indicating that heritable differences were obtained. The average seed-set of the clones was 40.2 and that of the inbreds was 14.9. This difference is highly significant. Of the 46 inbred families, the average seed-set was lower than that of the parent in 36 cases and higher in 10. These 10 families were all among the progenies of the 20 clones with the lowest seed-set. A clue to the causes of this reduction in seed-set under bag accompanying inbreeding is provided by the data on percentage seed-set. The average percent for the clones was 19.3 and for the inbreds 15.2. Of the 46 families, the percent seed-set of the inbreds was lower than that of their parents in 27 cases and higher in 19 cases. The differences between clones and inbreds are of doubtful statistical significance. Apparently the reduced seed-set under bag of the inbreds as compared with the clones may be attributed to a considerable extent to a general reduction in seed-setting ability, although there is evidence in addition of some decrease in self-fertility as a result of one generation of inbreeding.

In 1941, data were obtained from 33 second-inbred-generation families and the average seed-set of the I_2 plants was again reduced as compared with their I_1 parents. Since seed-set with open-pollination was not determined on these plants, it is impossible to draw conclusions regarding the causes of this decrease.

The results obtained to date may be summarized as follows: (1) there is a considerable range in ability to set seed under bag in orchard grass; (2) some of these differences are heritable; (3) the character exhibits such great random variation that it is very difficult to study; (4) there is, in general, a reduction accompanying inbreeding in number of seeds per panicle set under bag, much of which can be accounted for by a general reduction in seed-setting ability; and (5) this character proves to be a major obstacle in an inbreeding program.

Inheritance of Male-Sterility in *Dactylis glomerata*.
Data were obtained from crosses of three male-sterile plants of orchard grass (1938 Annual Report, page 31) with 5, 5, and 6 male-fertile plants, respectively. Male-sterility of one of the parents clearly was recessive to normal and possibly conditioned by a single factor, although the evidence is not conclusive on the latter point. The F_1 's involving each of the other male-sterile parents behaved in quite a different manner. In crosses with certain male-fertile parents, the F_1 was all male-sterile while in crosses with other male-fertile parents, the F_1 segregated with a majority of the plants male-sterile. Genetical explanation of this behavior must await the results of further investigations that are now in progress.

Varietal Improvement of *Dactylis glomerata*, *Lolium perenne*, *Phleum pratense*, and *Poa pratensis*

Evaluation of Plant Types. The use of short rows and small plots as a method of evaluation of plant types is being investigated in orchard grass and Kentucky bluegrass. In orchard grass, 50 clones were increased vegetatively and the plants of each clone spaced three inches apart in 6-foot rows distributed at random in three replications, the rows spaced one foot apart. In 1941, one end of each row (three feet) was clipped periodically with a lawn mower. The other half of each row was cut with a sickle at the hay stage. Striking differences among clones were observed in growth habit, leafiness under clipping and at hay stage, absence of extreme bunchiness, recovery following clipping, date of cut for hay, and amount of aftermath.

In Kentucky bluegrass, the 81 clones which had been tested previously in clonal plots (1940 Annual Report, pages 18 and 19) were used. In two replications, plants of the clones were spaced three inches apart in 3-foot rows which were two feet apart. In two additional replications, plots 2 feet by 3 feet were planted with seed at the rate of 15 pounds per acre. All rows and plots were established in the spring of 1940 and were clipped periodically with a lawn mower during 1940 and 1941.

Observational notes indicated that results from these small rows and plots compared favorably with those from the larger clonal plots. In view of the considerable saving of space and labor for establishment, this type of planting seems to have value where preliminary tests of large numbers of individual plants are desired.

Method of Reproduction in Poa pratensis. Open-pollinated progenies of 12 plants, averaging 34.2 plants per progeny, were classified. There was a range from 5.0 to 50.0 percent, with an average of .21.1 off-type plants for the 12 progenies. These results support conclusions drawn from previous investigations at the Laboratory that a higher degree of sexuality occurs in Kentucky bluegrass than has been reported by most other workers.

Second-generation progenies have established from 68 first-generation plants, some of which were selected from highly variable and others from the more uniform first-generation families. Data from these plantings will supplement that to be obtained from the progeny tests previously described (1940 Annual Report, page 18).

Progeny tests of additional selected plants were planted. These are part of the cooperative breeding projects with the Pennsylvania Agricultural Experiment Station and the West Virginia Agricultural Experiment Station and will be discussed in that section of the Report.

Genetical Investigations

Heritable Characters in Phleum pratense. It is shown elsewhere in this Report that plants of hexaploid timothy have a variable number of quadrivalents and occasional sexivalents at diakinesis and metaphase I. Such multivalent pairing should be reflected in the genetical ratios obtained. To test this hypothesis, seed of I_1 and I_2 progenies of seven plants were germinated and classified for albino and yellow seedlings. The numbers of I_2 families studied from each parent were 11, 22, 23, 23, 23, 25, and 26, respectively. The ratios obtained can not be fitted to those calculated on the basis of dihybrid and trihybrid inheritance. Evidently polysomic inheritance occurs. Plants of selected I_2 families have been placed in the field to provide seed for I_3 tests and thus afford more critical genetical evidence regarding the type of chromosomal association in timothy.

Heritable Characters in Dactylis glomerata. Because of the type of inheritance encountered in orchard grass (1940 Annual Report, page 21), characters which can be classified in the seedling or young plant stage are particularly desirable for many cytogenetical investigations with this species. Because of the dearth of useful marker genes which are available, considerable effort has been

expended in searching for additional ones. During the past year, I_1 progenies from 104 plants from open-pollinated populations have been established in flats in the greenhouse and observed for recessive types. Most of the progenies had one or more such recessives, many of which resembled phenotypically types which had been isolated previously. More detailed description of these characters will be reserved until their inheritance and allelism has been determined more completely.

Inheritance of Spotting in *Sorghum vulgare* var. Sudanense. Each of approximately 450 selfed lines of Sudan grass grown during 1941 showed either tan or red foliar spotting, depending on the color of the pigment carried by the line. Differences between selfed lines were noted in time of appearance of the spots, their shape, and frequency.

The parents as well as the F_1 , F_2 , and F_3 generations of crosses involving three types of spotting were grown and studied. No causal organism was found. As has been pointed out by others, tan was found to be a simple recessive to red. The inheritance data suggest that the time of appearance of spots, their general appearance, and the relative susceptibility of the host to them seem to be conditioned by a number of factors. The data collected have been summarized and prepared for publication.

Interspecific Hybridization in *Poa*. An F_2 population consisting of approximately 500 spaced plants has been established in the field from open-pollinated seed-set on the F_1 *Poa compressa* x *P. pratensis*. Extreme segregation was noted during the first season (1941) indicating that the F_1 was predominately sexual despite the fact that both parents were completely (or nearly completely) apomictic. More detailed analysis of the types obtained in F_2 will be made in 1942.

Cytological Investigations

Meiotic Behavior in *Phleum pratense*. Meiotic behavior was studied in the microsporocytes of 10 plants of hexaploid timothy. In six plants, from 9 to 36 diakinesis sporocytes were examined and the average pairing of the plants ranged from $14.20_{II} + 2.94_{IV} + 0.30_{VI}$ to $8.50_{II} + 4.86_{IV} + 0.9_{VI}$. The average chiasma frequency ($1/2$ chiasmata per chromosome) ranged from 1.67 to 1.90 and the correlation coefficient of bivalent with chiasma frequency

was 0.44, a value without statistical significance. Although little confidence can be placed in correlation coefficients based upon four degrees of freedom, it is perhaps significant that a positive correlation coefficient was obtained when a negative one might have been expected. The results suggest that some other factor, chromosomal differentiation perhaps, may have exerted greater influence than chiasma frequency upon variations in multivalent formation among these plants. In the remaining four plants, 1, 2, 4, and 5 diakinesis sporocytes were examined and multivalents were found in all. The individual sporocytes in the 10 plants ranged from 0 to 7 quadrivalents and 0 to 3 sexivalents. Although three sexivalents were the maximum in any one sporocyte, at least four of the chromosome sets are capable of associating in this manner. The six nucleolar chromosomes were associated frequently as a sexivalent while in the sporocyte with three sexivalents, the nucleolar chromosomes were not involved. In the 10 plants the percentage of MI sporocytes with unpaired chromosomes ranged from 1.1 to 14.3, the percentage of AI sporocytes with lagging and dividing univalents ranged from 0 to 23.1, and the percentage of quartets with micronuclei ranged from 0 to 15.1. Dicentric bridges and acentric fragments at AI indicated that five of the plants were heterozygous for one or more inversions. In the other five plants, the number of AI sporocytes recorded was too small to exclude the possibility of inversions, although no bridges and fragments were seen in the sporocytes examined.

Meiotic Behavior in *Lolium perenne*. Preliminary data have been obtained concerning the inheritance of partial asynapsis in perennial ryegrass. A partially asynaptic plant was crossed with a normal one and five F₁ plants were sib-mated to produce three F₂ populations of 10, 10, and 11 plants each. Metaphase I and anaphase I of microsporocytes from the five F₁ and 31 F₂ plants were examined. The ratios of regular to partially asynaptic plants in the three F₂ populations were 6:4, 8:2, and 8:3, suggesting a single recessive factor conditioning the character. Among the plants classified as partially asynaptic, the percentage of MI sporocytes with univalents ranged from 13.6 to 68.8, while the percentage of AI sporocytes with lagging univalents ranged from 15.8 to 80.9. Such extreme fluctuations suggest the operation of modifying factors. Further evidence for this hypothesis was obtained from comparing the average percentage of asynapsis and AI laggards in the F₂ populations.

To test the hypothesis of a single major factor plus modifiers, sib-matings of selected F₂'s and backcrosses of

selected F_2 's to the F_1 were made. Progenies of these crosses are being grown and will be examined cytologically.

Correlated Studies of Meiotic Behavior of Diploid and Induced Autotetraploid *Lolium perenne*. For studies of meiotic behavior in induced autotetraploid *Lolium perenne*, material produced by colchicine treatment of seeds (1938 Annual Report, pages 33 to 37) was used. For purposes of comparison, data were obtained from the tetraploid clone and from the diploid clone isolated from the same original seedling. In all, 11 pairs of tetraploid-diploid were studied. In the 11 autotetraploids, there was a range in chiasma frequency ($1/2$ chiasmata per chromosome) from 1.36 to 1.83, in quadrivalent frequency per microsporocyte from 2.92 to 4.83, in percentage of MI with univalents from 17.27 to 51.79, in percentage of AI with lagging univalents from 17.32 to 56.26, and in percentage of quartets with micronuclei from 24.97 to 56.59.

Correlation coefficients were calculated for all combinations of these characters. Only the correlation coefficient for MI univalents with AI univalents ($r = 0.628$) was statistically significant. However, certain others approached statistical significance and suggest possible relationships. Chiasma frequency was positively correlated with quadrivalent frequency ($r = 0.464$) and negatively correlated with percentage of MI sporocytes with univalents ($r = -0.546$). Quadrivalent frequency was not correlated with percentage of MI with univalents ($r = 0.105$) but was correlated with frequency of AI with laggards ($r = 0.535$). These results suggest that chiasma frequency is related to quadrivalent frequency and presence of univalents at MI. Variations in quadrivalent frequency are not related to unpaired chromosomes at MI but do contribute to frequency of laggards at AI. This is a significant point in view of the fact that there usually was found a higher frequency of laggards at AI than could be attributed to the unpaired chromosomes at MI.

The induced autotetraploid, *L. perenne*, does not differ in general from the natural autotetraploid, *Dactylis glomerata*, in quadrivalent or chiasma frequency. Two important differences have been noted. The autotetraploid, *L. perenne*, has on the average a higher frequency of unpaired chromosomes at MI and consequently more lagging at AI and AII. Furthermore, whereas disjunction at AI was usually numerically equal in *D. glomerata*, in 40 sporocytes counted of *L. perenne*, 52.5% had a 14-14 distribution, 40.0% had 13-15, and 7.5% had 12-16.

No statistically significant correlation coefficients were obtained between the features of meiosis studied in the diploids with those studied in the autotetraploid. The chiasma frequency per chromosome was lower in the tetraploid than in the diploid in 10 of the 11 pairs. This relation had been postulated previously but adequate critical data had not been available to support the hypothesis.

Comparative studies of frequency of dicentric bridges and acentric fragments yield evidence on the effect of inversions upon randomness of chromosomal association in an autotetraploid. All of the diploids showed evidence of being heterozygous for an inversion, the percentage of AI sporocytes showing bridges and fragments ranging from 0.20 to 11.12 in the different clones. Considerable fluctuation occurred in percentage of bridges and fragments in the tetraploid as compared with the related diploid. The average for the 11 diploids was 3.89% and for the tetraploids 3.98%. If the inversion does not have any effect upon randomness of pairing and on the assumption of an equal frequency of crossing-over in diploids and tetraploids, the frequency of bridges and fragments in the tetraploid should have been 1.33 times the frequency in the diploid. On this basis, the calculated value for the tetraploids would have been 5.17 compared with the obtained 3.98. Part of the lower frequency in the tetraploids probably can be attributed to lower cross-over frequency indicated by the reduced number of chiasmata. It may be concluded that a single inversion of the size used in these studies is not effective in completely inhibiting pairing in the autotetraploid, although the data suggest that there has been a slight influence.

Progeny of triploid *Lolium perenne*. Chromosome numbers of 72 of the plants from open-pollinated seed of the triploid plant (1940 Annual Report, page 22) were determined from the microsporocytes. The remaining 9 died before determination could be made. Of these, 4 were very abnormal and weak. Of the 72 plants, 12 were $2x$, 30 were $2x + 1$, 21 were $2x + 1 + 1$, 4 were $2x + 1 + 1 + 1$, 3 were $2x + 1 + 1 + 1 + 1$, and 2 were sectorial chimeras. Both of the latter two plants originally had very narrow, rolled leaves. Later sectors appeared with leaves of normal width. The original type of one plant was $2x + 1 + 1$ and the new sector was $2x + 1$. In the other plant, the original sector was so abnormal that sporocytes could not be obtained. The mutant sector was $2x + 1 + 1 + 1$. The narrow leafed original plants were similar to one of the trisomics and it was concluded

that the narrow leaf is conditioned by one of the chromosomes when in the trisomic condition. From this and previous evidence there appears to be a tendency for that extra chromosome to be lost in mitotic divisions.

The 30 trisomic plants could be classified into seven groups on the basis of morphological characteristics. The classes covered a range from the easily distinguished narrow leafed type to a type indistinguishable from normal. The chromosomes involved have not been identified yet cytologically and the classification into seven groups may be considered only provisional pending identification of the chromosomes.

Open-pollinated progenies of two trisomies were grown and their chromosome numbers determined from microsporocytes. Among the progeny of one, 18 plants were $2x$, 2 were $2x + 1$, and 1 was $2x + 1 + 1$. The origin of the double trisomic has not been determined, but since the trisomic parent showed a small amount of asynapsis, it is possible that the extra chromosome reached the gamete due to a meiotic irregularity. Among the progeny of the second trisomic, 9 plants were $2x$ and 8 were $2x + 1$. The trisomic plants were indistinguishable from their diploid sibs.

There have been planted 73 additional plants from open-pollinated seed of the triploid plant. Chromosome numbers of these will be determined when microsporocytes are available for study.

Variations in Meiotic Behavior among Plants of *Dactylis glomerata*. In continuation of the investigations of meiotic behavior in orchard grass (1940 Annual Report, pages 21-22), six of the plants studied previously were selected. Clones of these plants were growing in the field in three replications and the I_1 progenies were planted in adjacent rows. Sporocytes were collected from each replication of the parents in 1940 and again in 1941. In 1941, sporocytes were collected from three additional replicated clones. In 1940, sporocytes were collected from plants among the I_1 progenies of the 6 selected plants. Data were obtained from 5, 9, 10, 10, 12, and 13 I_1 plants. In 1941, material was collected from I_1 plants among the progenies of the three additional parents. From the material collected in 1940, data were obtained on frequency of quadrivalents, MI univalents, AI univalents, and micronuclei in the quartets. From the material collected in 1941, these same characters were studied and, in addition,

chiasma frequency at diakinesis was determined. An analysis of variance was calculated for each character from the data for the 6 clones which were studied during two years and in each case there were highly significant differences among clones. Also, the interaction of years x clones was highly significant statistically. There were highly significant differences among the nine clones in 1941 in chiasma frequency and the variations in chiasma frequency were not closely correlated with quadrivalent frequency.

Studies of the inbred progenies in relation to their parents revealed two important results: (1) the average of the inbred progeny was correlated with that of the parent in each of the characters studied, indicating that the differences were heritable; (2) the average quadrivalent frequency of the inbreds was very nearly the same as their respective parents but the average frequency of unpaired chromosomes at MI, laggards at AI, and micronuclei in the quartets was much higher in the inbreds than in the parents. Thus, meiotic irregularity was found to be increased following inbreeding. All of the data from the I_1 plants fixed in 1941 have not been collected and more complete analysis of the interrelations of characters of meiosis must await the completion of those data.

CYTOGENETICS AND BREEDING OF LEGUMES

Fertility Studies in Trifolium repens

Genetics of Pseudo-Self-Compatibility and Its Relation to Cross-Incompatibility. In the previous Report (1940 Annual Report, page 23), data were presented which showed that cross-incompatibility was conditioned by a series of oppositional alleles in pseudo-self-compatible plants, just the same as in self-incompatible plants. The only irregular results were with the original female parent. Further data have confirmed the hypothesis that this irregular plant had changed from the constitution S_4S_5 to S_4S_4 . By studying F_2 plants this past year in the field as well as in the greenhouse it has been demonstrated that the pseudo-self-compatibility of the original female parent was a heritable character, which was transmitted to the F_1 , F_2 , and backcross generation plants. This ability to set a few selfed seeds under certain treatments appears to be conditioned by several genes which were additive in effect and which were heterozygous in the parents. Since plants of both relatively high and low pseudo-self-compatibility were found in all six genotypes of not only the parents and F_1 but

also the F₂ generation, it is concluded that little relationship exists between the S factors and those conditioning pseudo-self-compatibility. The complete results of this study have been submitted for publication.

In connection with other genetic studies, a few inbred plants from pseudo-self-compatible parents were investigated in regard to their S factors, using as a test the diallel crosses in their F₁ progenies. It would be expected that half of all such first-generation inbreds would be homozygous and half heterozygous for the S alleles. Of the three inbreds thus investigated, two proved homozygous and one heterozygous.

Genetics of Self-Compatibility. From the F₁ diallel crosses in the 9-series, as described in last year's Report (1940 Annual Report, page 25), it was concluded that the original male parent was heterozygous for a self-compatibility factor (S_f), and that this gene is a member of the multiple allolomorphic S series. The results from this past year's study of F₂ plants have confirmed this theory. The different self-compatible genotypes in the F₁ were identified by backcrossing to the parental and F₁ groups, 48 F₂ plants, which had resulted from four F₁ intercrosses. A similar classification of these plants was effected through selfing in both greenhouse and field, although by some methods of selfing the influence of modifying factors was conspicuous. Certain of the self-compatible F₂ plants were found to be self-pollinating as well as self-compatible, i.e., they were autogamous. By appropriate genetic tests, it was also shown that representative first-generation inbreds, which had come from the original male parent, all bore the S_f gene no matter whether they had set few or many seeds per head after selfing in the field. Some of these plants with the lower seed-set were effectively male-sterile because of hard anthers. From appropriate tests with plants which were homozygous for incompatibility alleles, it was concluded that S_f is dominant over the second allele carried with it in a heterozygous plant. The presence of S_f in pollen, however, did not stimulate other pollen applied with it. A paper presenting these results has been submitted for publication.

A few other plants have been found which, by progeny test, appeared to have self-compatibility genes similar to the S_f just described, but in no case were as many selfed seeds obtained consistently from these plants as were obtained from the original male parent and its self-compatible descendants.

Alleles Causing Cross-Incompatibility. Since previous work (1940 Annual Report, page 24) had indicated that the number of alleles causing cross-incompatibility in white clover was large, a more refined test was made, using two series of plants. The first consisted of 10 individuals selected from the Laboratory's breeding nursery. The second series were 17 plants selected by Professor H. B. Sprague for use in the cooperative breeding program. In both cases, the plants were of extremely wide geographical origin so that there was very little probability of their being related. When these 27 plants were crossed with a plant homozygous for oppositional alleles (S_1S_1), all matings were compatible. In 26 of the 27 resultant F_1 progenies of 4 to 8 plants each, two intra-sterile, interfertile groups were found, while in the other progeny only one group was found. Within each series, all F_1 groups were mated diallely and each F_1 group or its heterozygous parent was crossed as a female with six plants, homozygous, respectively, for six other alleles. Incompatible matings between any two plants indicated that the two alleles being tested were identical. Of the 26 alleles tested in the first series, 25 (96%) proved to be different and in the second series, 34 (83%) of the 41 were different. A detailed report of this work has been submitted for publication. For a continuation of this study, two collections of plants have been made in locally-confined natural populations of white clover.

"Natural Crossing" under Bee Cages. Enclosed under eight bee cages in the field last summer were eight plants with different degrees of pseudo-self-compatibility, each with recessive solid green leaves. Also in each cage were clones of another plant, which was homozygous for a dominant white marking on the leaf. Seed was harvested from the recessive plants, and the seedlings were grown for classification this past fall. Although the data are not completely analyzed, it is evident that all plants showed a very high percent of natural crossing (over 97%), except the plant with highest pseudo-self-compatibility, in which case there was about 80% crossing.

Effect of Temperature on Cross-Incompatibility. Since temperature had been shown in other species to have a pronounced influence on pollen tube growth, a test was made to determine its effect on cross-incompatible matings in white clover. Clones of several plants, some of which were homozygous and others heterozygous for oppositional alleles, were used in this study. For each treatment several heads

on each plant either were selfed or were crossed with another plant of the same incompatibility group and, at the same time, several other heads were crossed using pollen from a compatible plant. Immediately after pollination, the different plants were placed in daylight chambers, with constant temperatures of 10°, 15°, and 30° C. and for periods of 24, 48, and 72 hours at each temperature. As checks, plants also were kept in the greenhouse maintained at about 20° C. Among the incompatible matings, no temperature treatment induced more seed to set than was obtained at 20°. Likewise, the various temperature treatments had no effect on the seed-set in compatible matings.

Varietal Improvement of Trifolium

Inbreeding Studies. The planting of inbreds in 1941 consisted of (1) 90 second-generation lines of white clover, (2) 12 first-generation lines of white clover, (3) 7 second-generation lines of Ladino, and (4) 12 first-generation lines of strawberry clover. The planting was in three randomized blocks for each group of lines and there were about 30 plants to a line. Interplanted were clonal rows of the corresponding parents, and of the I_1 parent in the case of the I_2 lines. Because of the drought in both spring and fall, growth was subnormal and no systematic notes will be taken until next summer.

Further observations were made, however, on the inbreds in the 1940 nursery. Among the second-generation lines, the average decline in vigor in comparison with the original parents was nearly 40%. Certain lines lost less than 20%, while others showed a decline of almost 80%. The first-generation lines in this same nursery were slightly less than 70% as vigorous as their parents.

Over 7,900 bags were used for selfing in the nursery last summer, with the greatest share of them on inbred plants or their parents. Representative plants in each row were bagged, not only to perpetuate the line but also to measure roughly the self-compatibility in different plants. These data are not summarized completely, but it appears, as in previous years, that some lines will be lost because of decreased fertility, whereas others may be maintained because of the high seed-set from certain individuals. These observations are being correlated wherever possible with the evidence cited above on the genetics of pseudo-self-compatibility and of self-compatibility.

New Sod Plots. In the summer of 1940 there were selected 100 white clover plants, which appeared to be especially vigorous types in their third summer of growth. They were of very diverse origins, 34 coming from the sod-plugs collected in the Northeast, 14 from white x Ladino hybrids, and 52 from foreign introductions. Cuttings from all of these plants were used to start sod-plots last spring in the same manner as that followed in 1938.

Combining Ability of Sod-Plot Selections. From the 1938 white clover sod plots, there were selected 10 good, 10 medium, and 10 poor yielding individuals. The good plants were diallely crossed, and the medium and poor plants were chain-crossed in the greenhouse. The resultant seedlings were spaced out in small plots for clipping. Due to loss from damping off, however, not all combinations were obtained so that a further attempt to obtain additional seed was made last summer, and another attempt is being made this winter.

Ladino Clover Collections. In 1940, Ladino seed heads were collected in pastures throughout the Northeast. Five seedlings were grown from each of the 10 to 20 heads collected in each of 22 fields. This material will be used for a survey of variability and as a source of breeding material. The only notes taken so far were on the damage from a leafhopper infestation. Not a plant of Ladino was completely free from injury, whereas white clover growing adjacent was not at all visibly damaged.

Genetical Studies in Trifolium repens

Marker Genes. Of the several leaf markings reported on previously, the only one investigated further this past year was the purple leaf character. Thirty-one F_2 plants, all showing the dominant purple color, were backcrossed to their recessive solid green parent. Progenies from 19 plants segregated, giving a total of 519 purple seedlings and 530 greens. The other 12 F_2 individuals proved homozygous for purple, since all 553 of their progeny were purple.

Studies were also begun with several mature plant markers. Intercrosses were made in F_1 populations involving (1) supernumerary leaflets; (2) a yellowing of the flowers, due to drying at the petal edge; (3) two different lines with red flowers; and (4) two different lines with "unopened petals." Damping-off here again restricted

the field planting, but F_2 and backcross generations were set out wherever available. All characters appeared recessive in the F_1 except for one line of the red flowers, which gave some pinks in the F_1 , and one line of unopened petals gave an F_1 with this abnormality completely dominant. In the latter case, the F_1 plants varied from a condition of complete blasting of the head to one where very small petals were visible. The abortion of stamens and pistils, however, was so complete on all of these plants that no seed was obtained.

HCN Tests of Inbred Lines and Crosses. Previously, (1940 Annual Report, page 27) the F_2 and backcross results of the HCN study were described, and it was stated that they appeared to confirm the single factor hypothesis proposed by Williams, although considerable deviation from expected ratios was obtained. Within the past year, however, there has appeared from New Zealand published work which describes plants which may be lacking in the enzyme, the glucoside, or both. Using an enzyme and a glucoside prepared according to the New Zealand directions, a similar situation was found in the plants studied in the nursery this past summer. These individuals had resulted from backcrossing to their original acyanogenetic parent 22 F_2 plants, which had been selected because they all gave a 4 (high HCN) reaction like their male parent. When these backcrossed plants were first tested, without the addition of either glucoside or enzyme, the segregations were very irregular, and only one of the 22 F_2 plants appeared to be breeding true for HCN. The tests were then repeated with the enzyme being added, and many plants which had previously tested 0 gave a 3 or 4 reaction. According to the new classification, six F_2 plants continued to show segregation similar to that formerly obtained (73:39 instead of 75:37), nine other F_2 plants changed in the proportion of 0 plants but still showed a definite segregation (106:78 instead of 63:121), and the remaining seven plants appeared homozygous (186 + instead of 124:62). In contrast with this, few definite results were obtained by adding the glucoside, probably because the preparation used was not sufficiently concentrated. It is evident from these results that the F_2 population was segregating not only for the Ac/ac pair of factors but also for a gene conditioning enzyme development. Since there was no good way of retesting the F_2 , another cross has been made, using as one parent an F_2 plant homozygous for both enzyme and glucoside and as the other an F_3 individual having neither enzyme or glucoside.

There were also tested in the field last summer 10 first-generation and 12 second-generation inbred lines, all of whose parents had shown a positive test for HCN. Segregation was observed in 19 of the lines, while the other three appeared to be breeding true. As in previous tests of inbreds, considerable deviation was observed in the amount of color in the "positive" tests, possibly indicating the segregation of definite modifying factors.

Inheritance of Rust Resistance. Described in last year's Report (1940 Annual Report, page 28) is the field planting, on which notes were taken this past summer to study the inheritance of rust resistance. A severe and uniform epiphytotic was obtained ~~on~~ that classification of the plants appeared quite certain. About 100 clones from each of the four parents were grown, and in every case the classification throughout was identical with the readings obtained on these plants in previous years. From 14 to 30 additional first-generation inbreds from each of the four parents were also classified, and in every case the progenies were uniform throughout. The parents, as in the 1938-39 nursery, seemed to be breeding true for resistance or susceptibility. In contrast with this evidence, among F_1 plants there was variation from complete resistance to complete susceptibility. The different crosses varied from about one-sixth of the plants resistant to over half resistant. The grand total for the F_1 was 67 resistant and 140 susceptible. Likewise, the F_2 generation, which resulted from intercrossing F_1 plants, varied from complete resistance to complete susceptibility. In some crosses the ratios between resistant and susceptible plants were about 1:1, whereas in others they approached 1:2. For the entire F_2 population the ratio of resistant to susceptible was 250:329. Each of the F_1 plants used as immediate parents of the F_2 was also backcrossed to its resistant parent. The resulting population was shifted considerably towards resistance, the ratio being 333 resistant to 276 susceptible. No factorial explanation for these results can be formulated at present. To obtain further evidence, 40 F_2 plants varying in amount of rust were selected, and they will be backcrossed to both parents this winter.

Cytological Studies

Studies on the regularity of pairing and disjunction in the microsporocytes of 64-chromosome plants of white clover have been continued. The data are not complete for all plants, but it is evident that quadrivalents are formed in all plants examined.

A number of trisomic plants were found among the open-pollinated offspring of the triploid red clover. More seedlings are being grown this winter for cytological analysis.

Four triploid alsike clover plants were obtained from the $4n \times 2n$ cross. Open-pollinated seed was obtained on these plants last summer, and some of it has been started for cytological analysis.

The studies with the trisomic plants of sweet clover have been continued.

PHYSIOLOGY AND COMPOSITION OF PASTURE PLANTS

Effect of Temperature on Germination and Early Seedling Establishment

In the fall of 1941 an experiment was begun in the environmental control chambers (see pages 2-3 and figure 1) to study the effect of temperature and daylength on germination and early seedling establishment of pasture species, including Sudan grass, orchard grass, meadow fescue, bromegrass, Kentucky bluegrass, timothy, colonial bent grass, and Ladino clover. The complete experiment will include seeds planted and grown at alternating temperatures of $40-55^{\circ}$ F., $55-70^{\circ}$ F., $70-85^{\circ}$ F., and $85-100^{\circ}$ F. The soil temperatures will be maintained the same as the air temperatures and the relative humidities will be regulated so that the same vapor pressure deficit will prevail under all temperatures. The control cans will be so cut that the maximum and minimum temperatures will be maintained for four hours each and eight hours will be allowed for the transition. This places the mean temperatures for the series at 47.5° , 62.5° , 77.5° , and 92.5° F. One series of the above temperatures will be grown under a 16-hour day and another under a 9-hour day, with the illumination coinciding with the maximum temperatures. Fifty plump seeds of each species will be planted in each pot and allowed to germinate. Pots of each species will be removed 2, 4, and 6 weeks after the emergence of the first seedling and measurements taken of the number of seeds germinated, the number and height of leaves, the length of roots, and total dry weight of roots and tops.

The results at the two higher temperatures, viz., $70-85^{\circ}$ F. and $85-100^{\circ}$ F., have been obtained and are presented in this Report. The two lower temperatures have not yet been completed. (See figure 2 showing growth of Sudan and orchard grass at higher temperatures).



Sudan Grass



Orchard Grass

Fig. 2. Plants six weeks after germination grown under controlled temperatures and daylengths. The cultures grown at 85-100° F. and under a 16-hour day are not shown. Under such conditions the growth of Sudan grass was greater than at 70-85° F. under a 9-hour day, but the orchard grass was killed.

Table 2. The percentage germination obtained under different temperatures and daylengths (average of 6 replications).

Species used	85-100° F.		70-85° F.	
	16-hr.day	9-hr.day	16-hr.day	9-hr.day
	%	%	%	%
Sudan grass	77.6	80.9	73.6	79.6
Brome grass	47.6	83.9	92.2	90.2
Ladino clover	4.6	17.6	76.6	74.6
Timothy	7.0	39.9	72.6	74.3
Meadow fescue	54.6	88.9	90.6	94.6
Orchard grass	11.9	32.9	58.3	62.6
Kentucky bluegrass	0	0	12.6	17.3
Colonial bent grass	0	0	22.6	21.3

It is evident that the percent germination of all species except Sudan grass is reduced by temperatures of 85°-100° F. The reason for the lower germination under a 16-hour day compared to a 9-hour day at the high temperature has not been determined but it is probable that the illumination increased the soil temperature slightly above the controlled setting and that under a 16-hour day this increase in temperature persisted for a longer time. Inasmuch as the temperature of 85°-100° F. is critical, a slight increase above this point or its continuance for a slightly longer period may account for a higher mortality. Even though brome grass and meadow fescue germinated about 50% at the high temperature and long-day conditions, they did not grow and most of them were dead at the end of six weeks. Kentucky bluegrass and colonial bent grass are especially sensitive to high temperatures, showing a poor germination even at 70-85° F.

It is apparent from table 3 that temperatures of 85-100° F. are extremely unfavorable for the growth of all the species used except Sudan grass, most of them producing no growth under a 16-hour day and very limited growth under a 9-hour day. As mentioned above in the discussion of germination, the cause for the decrease under a 16-hour day has not been determined but it is probable that the increased light may have increased the temperature and also its duration under conditions which were already critical. Even at 70-85° F. the growth of Kentucky bluegrass and colonial bent grass seems to be seriously inhibited.

Table 3. The amount of root and top growth produced in six weeks at the two higher temperatures and at two daylengths.

		Average yield per plant 6 wks.					
		after emergence					
		85-100° F.			70-85° F.		
		16-hr.day	9-hr.day		16-hr.day	9-hr.day	
Sudan grass	:Tops, mgs.	: 120.3	: 56.0	:	: 122.1	: 87.05	
	:Roots, mgs.	: 44.1	: 10.75	:	: 56.1	: 31.9	
	:Root/top ratio:	: 0.366:	: 0.192:	:	: 0.459:	: 0.366	
Brome grass	:Tops, mgs.	: tr	: 4.74	:	: 28.41	: 13.69	
	:Roots, mgs.	: tr	: 0.89	:	: 15.11	: 4.25	
	:Root/top ratio:	: -	: 0.188:	:	: 0.532:	: 0.310	
Ladino clover	:Tops, mgs.	: 0	: 0	:	: 20.84	: 3.75	
	:Roots, mgs.	: 0	: 0	:	: 5.63	: 0.82	
	:Root/top ratio:	: -	: -	:	: 0.270:	: 0.218	
Orchard grass	:Tops, mgs.	: 0	: 1.35	:	: 19.26	: 5.05	
	:Roots, mgs.	: 0	: 0.24	:	: 7.60	: 1.23	
	:Root/top ratio:	: -	: 0.177:	:	: 0.395:	: 0.244	
Timothy	:Tops, mgs.	: 0	: 0.656:	:	: 6.672:	: 2.975	
	:Roots, mgs.	: 0	: 0.129:	:	: 2.163:	: 0.630	
	:Root/top ratio:	: -	: 0.196:	:	: 0.324:	: 0.212	
Meadow fescue	:Tops, mgs.	: 0	: 1.69	:	: 26.6	: 8.39	
	:Roots, mgs.	: 0	: 0.20	:	: 11.04	: 1.96	
	:Root/top ratio:	: -	: 0.118:	:	: 0.415:	: 0.233	
Kentucky blue- grass	:Tops, mgs.	: 0	: 0	:	: 4.86	: 1.88	
	:Roots, mgs.	: 0	: 0	:	: 1.48	: 0.393	
	:Root/top ratio:	: -	: -	:	: 0.304:	: 0.209	
Colonial bent	:Tops, mgs.	: 0	: 0	:	: 3.975:	: 0.786	
	:Roots, mgs.	: 0	: 0	:	: 1.162:	: 0.219	
	:Root/top ratio:	: -	: -	:	: 0.292:	: 0.279	

The relationships between temperature, daylength, and the root-top ratios are interesting. In all cases, the ratio is decreased by the shorter daylength and is similarly decreased by an increase in temperature.

The growth rates for the various species obtained by plotting the increase in total dry matter produced under 70-85° F. and a 16-hour day at intervals of 2, 4, and 6 weeks indicate the definite exponential curve usually obtained. Under the less favorable conditions the curve tended to flatten and under 85-100° F. and a 9-hour day, it became almost a straight line in all cases except Sudan grass.

Effect of Supplementary Light on Flower and Seed Production in Trifolium repens

The question has arisen as to the value of continuing supplementary lighting to increase the daylength once floral primordia have been initiated. The experiment outlined below was conducted to determine the effect of continuing supplementary illumination for different lengths of time after flowering had been initiated.

Seven series of white clover plants were established under a long day and each shifted to normal daylength at one of the following periods: (1) when floral primordia could first be detected by dissection, (2) when buds first appeared externally, (3) at pollination, (4) one week after pollination, (5) two weeks after pollination, (6) three weeks after pollination, and (7) four weeks after pollination, which was at the time the seed was harvested. The approximate duration of the long day for the seven treatments was 3, 5, 7, 8, 9, 10, and 11 weeks, respectively. Enough supplementary light was added during this period by 100-watt Mazda lamps to extend the "day" to approximately 17 hours and to provide about 75 foot-candles at the soil surface. Within each treatment were included three pots of each of two cross-compatible plants, which had been shown in previous studies to flower well under a 17-hour day. Each of the seven treatments were carried out in two greenhouse sections, one held at about 60° F. night temperature and the other at about 70°. Pollinations were carried out only in the 70° section. The two plants within each treatment were crossed reciprocally, using eight heads per plant. The resultant seedlings were germinated in sterile sand to observe seedling viability.

The total number of flower heads were counted for each pot. In general, the greatest increases in number of flower heads produced in relation to the duration of the long day occurred up to the time of pollination.

At the 70° F. temperature, the number of heads increased for one clone from 77 for treatment (1) to 103 for treatment (3). The heads on the other clone increased from 166 to 224 for the same treatments. While there was a further increase in number of heads with increased duration of the long-day conditions, this increase is probably of limited value in greenhouse techniques. Since one clone produced over twice as many heads as the other, the results from the two clones were analyzed separately. In the case of one clone, the variance between treatments exceeded the 5% point only at the 70° temperature, while the variance between temperatures exceeded the 1% point. With the other clone, the variances between treatments as well as temperature exceeded the 1% level of significance.

While no difference in size or plumpness of seed was detected by observation, careful weighing of the seed indicated a slight increase in weight from 0.67 mgn. of seed produced under treatment (1) to 0.77 mgn. of seed produced under treatment (7) from one clone and from 0.57 to 0.62 mgn. of seed for the other. Statistical analyses of these data indicated a significance exceeding the 5% point for light treatments and exceeding the 1% point for reciprocal crosses. This suggests that while the size of seed increased with duration of the photoperiod, it has little practical significance since the size of seed produced by different plants exceeds the difference due to treatments.

The results of the germination studies indicated little if any practical significance to differences between light treatments. For the seedlings the differences between plants exceeded the difference between treatments. Statistical analysis of the data on 9-day old seedlings indicated a variance for interaction of crosses and treatments exceeding the 5% level of significance, but the variance for treatments did not attain this level. The stand at three weeks showed a variance exceeding the 5% level of significance for both crosses and treatments.

It is concluded from the above data that it would usually be advisable to maintain the plants under a long day until the time of pollination, but that the increase in number of heads produced or any increase in weight of seed is not sufficient to warrant the cost of continuing the long-day conditions beyond this time.

The Effect of Several Pretreatments on Heading

During the winter of 1940-41, studies were continued to determine the effectiveness of different pretreatments in promoting heading of orchard grass (1938, 1939, and 1940 Annual Reports). The heading abilities of the six clones of orchard grass used were known to range from no heading under a normal winter day (9 to 10 hours of daylight) in the greenhouse to heading under a 12-hour day as well as a 16-hour day. Material from these clones was started in gravel cultures at various intervals during November and December so that all clones would be subjected to the same environmental conditions during the heading trials. The pretreatments involved varying the length of time at which plants were allowed to grow under a short day (9 hours) and the duration of a subsequent cold treatment (at $+1^{\circ}\text{C}$. in darkness). The pretreatments were as follows:

Weeks under short day	Weeks in cold room
10	7
10	4
10	0
7	7
7	4
7	0
0	0

At the termination of the pretreatment period the plants were grown under daylengths of 10, 12, 16, and 20 hours and the heading date and number of heads recorded.

A summary of the results follows:

1. No heading was obtained on any clone which had not been previously subjected to a short day.
2. Increasing the length of the pretreatment growth period at short day increased the number of heads produced.
3. Increasing the duration of the cold treatment also increased the number of heads produced, particularly at the longer period of growth under short days.
4. An increase in daylength from 16 hours to 20 hours did not consistently increase the number of heads produced. In some cases it actually decreased the number of heads. Plants receiving a 20-hour day headed several days sooner than those receiving 16 hours.
5. Only a few plants headed under a 12-hour day and those were from clones which had previously headed under this daylength.
6. No heading was observed at a photoperiod of 10 hours.
7. None of the pretreatments used was effective in inducing two of the clones to head which in previous trials had not headed in the greenhouse.

Growth Interactions of Dactylis glomerata and
Trifolium repens, var. latum

During the summer of 1941 a greenhouse experiment was conducted to determine the effect of four clones of orchard grass on the growth of plants from a commercial lot of Ladino clover and also the effect of the Ladino on the growth of the orchard grass. The four clones of orchard grass used were selected on the basis of their behavior in field plots. Two of the clones had allowed the Ladino clover to grow well in association with them, while the other two clones almost prohibited the growth of the clover. The morphological habits of the orchard grass did not seem to be the causal factor for this difference.

All material was grown in gravel cultures supplied with a well-balanced nutrient.

The cultures were so arranged that one series of orchard grass and Ladino clover was supplied with nutrient from separate sources while in the other series the same nutrient was in contact with the roots of both species. This allowed a comparison which would indicate whether the orchard grass or clover released anything during growth which inhibited the growth of the other. The nutrient was not changed during the course of the experiment in order to allow any substances given off by the plants to accumulate. Water was added to replace losses by transpiration and the concentration of the mineral constituents and nitrogen was maintained by analyzing the solution every two weeks and adding the required amounts of stock solutions.

The plants were grown during June, July, and August at a time when greenhouse temperatures were high and not particularly favorable for growth of either species. Clippings were made at about monthly intervals at a height of 1-1/2 inches and dry weights recorded. At the last clipping date the cultures were broken up and the dry weights of roots and stolons or stubble were determined.

The results of this experiment may be summarized as follows:

1. The yield of clover supplied with nutrient from the same bottle as that which supplied two of the grass clones was similar to that obtained when the nutrient was supplied from individual nutrient bottles. Two other grass clones slightly reduced the clover yield.

2. The yields of the clones of grass when supplied with nutrient from individual bottles as compared to the same clone supplied from bottles also supplying the clover were in three cases about the same, but yield of the fourth grass clone was reduced.
3. Root and stubble or stolon weights were in relationships similar to the top growth.
4. No definite indication of harmful substances given off by the roots of either plant was demonstrated, although one clone of orchard grass suggested such a relationship.
5. The growth responses in the greenhouse of two of the orchard grass clones coincided with their field behavior; the other two were inconclusive or opposite in reaction.

The Effect of Doubling the Number of Chromosomes in
Trifolium repens upon the Chemical Composition

Additional analyses were made upon samples of white clover plants grown from 32- and 64-chromosome slips in the field during 1940 (1940 Annual Report, page 35).

Increasing the number of chromosomes lowered the crude fiber content. The difference was highly significant statistically. The complete data have been summarized in table 4.

Table 4. The effect of doubling the number of chromosomes on the chemical composition of white clover. Average analyses of 10 clones.

	No. of chromosomes		t value for
	32	64	difference
<u>July 1940</u>			
Moisture, in % of fresh wt.	: 75.73	: 76.39	: 2.77
Total N, in % of dry wt.	: 3.73	: 3.78	: 1.49
Ash, " " " " "	: 13.85	: 14.07	: .90
Fat, " " " " "	: 2.04	: 2.11	: .18
Fiber, " " " " "	: 13.58	: 12.97	: 29.05**
N-free extract, " " "	: 47.17	: 47.30	: .23
Carotene, p.p.m., dry wt.	: 416	: 409	: .34
<u>Sept. 1940</u>			
Carotene, p.p.m., dry wt.	: 403	: 371	: 4.91*

*Significant

**Highly significant

The Effect of Leaf Rust /Uromyces trifolii trifolii-
repentis (Liro) Arth./ upon the Chemical
Composition of Trifolium repens

Additional analyses have been made upon rusted and rust-free plants of white clover collected in the field during 1940 (1940 Annual Report, pages 41-43).

Rusted plants were higher in crude fat, lower in crude fiber and in nitrogen-free extract than rust-free plants of the same clones which had been protected with sulfur. The effect of sulfur upon rust-resistant clones has been to decrease the fat, and increase the fiber and the nitrogen-free extract. The comparison of rusted plants with rust-free plants which had been treated with sulfur is, therefore, complicated by the effect of the sulfur and the significance of the effect of the rust is rendered doubtful for the above constituents.

In a comparison of heavily rusted, lightly rusted, and rust-free leaves from the same plant (no sulfur present), all the rusted leaves are higher in fat, fiber, and nitrogen-free extract and lower in crude protein than the rust-free leaves. All the differences are highly significant statistically.

Carbohydrate Metabolism of Grasses

The carbohydrate changes in the roots and stubble of perennial ryegrass were studied in relation to the regeneration of growth after defoliation. After plants were well-established in gravel cultures, they were clipped at 1.5 inches from the ground level. One series of plants were allowed to recover in the greenhouse and a duplicate series were placed in complete darkness and the temperature maintained at 17° C. Entire plants were harvested from both series at the time of clipping and thereafter at intervals of 1, 2, 4, 7, 11, 16, 22, 28, and 36 days, at which times roots and stubble were taken for chemical analysis and yields of total dry matter. Only oven-dry weights were obtained of the new top growth produced after clipping.

The average dry weight of the roots per pot of the series recovering in the greenhouse increased from 20.3 grams at clipping to 28.9 grams after 36 days. The increase in weight did not begin until the fourth day. The

dry weight of stubble dropped from 12.3 grams at the time of clipping to a minimum of 10.7 grams at 11 days, then increased to 18.9 grams at 36 days. New growth of tops began immediately and the yield of dry matter increased to 11.2 grams in 36 days.

The carbohydrate content of the roots and stubble decreased rapidly at first and then recovered. In the roots, fructose decreased from 0.8% to 0.2% in 10 days, then increased to 0.4% at 28 days; glucose never exceeded 0.3%; sucrose decreased from 1.7% to a minimum of 0.7% at four days, began to increase rapidly at 16 days and reached 2.7% at 28 days. All the sugars decreased between 28 and 36 days in proportion to the amount present. Alcohol-insoluble fructosans decreased from 1.9% to a minimum of 0.6% at 10 days, increased to 2.0% at 28 days, then remained at the same level.

The stubble was considerably higher than the roots in all forms of carbohydrate. Fructose decreased from 1.8% to a minimum of 0.8% at 11 days. It did not recover thereafter. Glucose decreased from 2.0% to 0.8% at 7 days, increased to 1.9% at 28 days, followed by a decrease. Sucrose rapidly fell from 3.3% to 1.6% at 7 days, rose to a maximum of 3.6% at 28 days and decreased. Fructosans of the stubble began at 15.0%, dropped to 2.5% at 11 days, began rising at 22 days, and were still rising at 36 days at 9.6%.

The dry weights of the roots and stubble of the plants placed in a dark room immediately after the original clipping decreased in weight to a minimum of 13.8 grams for the roots and 6.0 grams for the stubble after 36 days. The plants had died by the time the last harvest was made. The rate of top growth was as rapid as for the plants in the light for the first 4 days but not thereafter. A maximum yield of tops was 2.9 grams at 22 days. The carbohydrate content of the darkened plants decreased rapidly and did not recover, all fractions reaching negligible levels after 36 days.

From these incomplete data it is apparent that, during the period of regeneration of top growth which began immediately following clipping, the carbohydrate contents of the roots and stubble underwent a considerable decrease for a period of about 10 days. Thereafter

restorage of carbohydrates occurred. The total dry weight of the roots did not fall below their original value; that of the stubble did, but soon recovered. Considerably more carbohydrate was present at all times in the stubble than in the roots.

Phosphorus Fixation in Soil as Affected by Temperature

Last year it was reported that increasing the soil temperature resulted in a greater degree of phosphate fixation (1940 Annual Report, page 38). A paper reporting the results of those studies has been submitted for publication.

This year, experiments were started to determine the importance of temperature in relation to:

1. Phosphorus fixation by various soils
2. The rate of phosphorus fixation
3. The total amount of phosphorus fixed

The soils used in the study were as follows:

1. Dekalb, unlined
2. Dekalb, lined
3. Dekalb subsoil
4. Hagerstown, heavily lined
5. Hagerstown subsoil
6. Orangeburg soil from Florida
7. Kaolin

These soils were fertilized with mono-calcium phosphate at different rates and incubated at optimum moisture content at (1) 3° C. and (2) 40-45° C. The length of the incubation period ranged from one week to 17 weeks. One series received no incubation treatment, the fertilizer being applied at planting time.

At the conclusion of the incubation period, phosphorus fixation will be determined by the growth of Ladino clover and also by laboratory methods.

Clonal Variations in the Yields of Roots and Rhizomes of Poa pratensis

In 1938 plots were established with each of 81 different clones of Kentucky bluegrass and then seeded uniformly with white clover. During 1939-41 the plots were clipped periodically with a lawn mower set to cut to a height of one inch. Yields of dry matter were determined in 1940.

In the fall of 1941 thirteen clones were selected for the determination of subterranean growth. These 13 clones included some of the highest yielding and some of the lowest yielding ones, based on the performance during 1940.

A sample of sod about 6 inches square and 8 inches deep was taken from each plot. These samples were subdivided into the 0-3 inch layer of soil and the 3-8 layer. Each sub-sample was soaked in water overnight and the roots and rhizomes washed free of soil. One of the four samples from each clone was subdivided into roots and rhizomes. Since it was impossible to wash the samples entirely free of soil, they were ignited and the loss of weight taken as a measure of the yields of roots and rhizomes.

The samples from the 0-3 inch depth showed highly significant clonal differences in total roots plus rhizomes. The yields (loss on ignition from the 13 clones ranged from 1,702 to 4,444 pounds per acre. It is interesting to note that the clones that gave the highest yields of roots were the ones that gave low yields from clipping in 1940. There was also some indication of a negative correlation between yield of rhizomes and yields of clipping.

The differences in yields of roots plus rhizomes in the 3-8 inch layer (there were few rhizomes at this depth) were not significant. The average yield (loss on ignition) was about 725 pounds per acre.

Clonal Variations in the Calcium and Phosphorus Contents of Trifolium repens in Relation to Environment

Last year it was found that clones of white clover which were relatively high in percentage calcium or phosphorus when grown on one soil in the greenhouse were also relatively high in percentage calcium or phosphorus when grown on other soils in the greenhouse (1940 Annual Report, page 39).

This year, studies were conducted to determine if these relative differences in calcium and phosphorus content are maintained under varying climatic conditions. The investigations were conducted on a fertile Hagerstown soil both in the greenhouse and in the field, using the same eight clones of clover that were used last year.

For one series of greenhouse studies cuttings of the eight clones were started in pots on November 10, 1939, and four successive clippings taken from each pot. The dates of sampling were February 9, March 19, April 29, and May 31. From the time the experiment was started until the latter part of March, Mazda light at an intensity of about 100 foot-candles was supplied to increase the length of day to 13 hours. None of the clones flowered during this period.

In a second greenhouse experiment these same eight clones were taken from the field and started in pots in the greenhouse on July 30, 1941. The clover was harvested on August 20 and again on October 4. Most of the clones were flowering in the field on July 30, but flowering practically stopped when the plants were taken to the greenhouse.

The field samples were obtained from plots of the pure clones established during 1940. Samples from these plots were taken once in 1940 and four times during the season of 1941. The plants were not flowering when the samples were taken in the spring of 1941. At all other sampling dates most of the clones were flowering, but the flowers and flower stalks were not included in the samples.

Some of the data obtained in this study are given in tables 5 and 6. With wide variation in environmental conditions, differences in percentage calcium and phosphorus content were obtained. Based on the average for the eight clones the range for different sampling dates was from 1.56% to 2.28% for calcium and from 0.258% to 0.376% for phosphorus. In general, the samples from the field were slightly lower in percentage calcium than those from the greenhouse, but for percentage phosphorus content the differences between plants grown in the greenhouse and those grown in the field were small in comparison with the differences among various sampling dates.

In general, the clones that were high in percentage calcium and phosphorus at one sampling date tended to be high in percentage calcium and phosphorus at other sampling dates. Thus, in each of the 11 comparisons clone No. 15(31) was higher in percentage calcium than No. 56(3). Similarly, No. 33(37) was consistently higher in phosphorus content than clone 56(104). On the other hand, some clones were relatively higher in calcium or phosphorus content at

one sampling date than at another. For example, under some conditions clone No. 15(31) was higher in percentage phosphorus than No. 56(3), whereas under other conditions it was lower. Similarly, clone 56(104) was sometimes higher in percentage calcium than No. 44(11) and at other times it was lower. These latter two clones are particularly interesting in that during the warmer periods, characterized by the cuttings made on May 31 and August 20 in the greenhouse and those made in June and July in the field, the calcium content of the two clones was about the same. During the cooler periods, such as in the winter in the greenhouse and in the spring and fall in the field, No. 56(104) was considerably higher in calcium than No. 44(11).

Table 5. The calcium content of different clones of white clover at various times during the year, both in the greenhouse and in the field.

Source	Date	Percentage Calcium					
of	of	Clone	Clone	Clone	Clone	Av. of	
sample	sampling	15(31)	56(3)	56(104)	44(11)	8 clones	
Greenhouse	Feb. 9, 1940	2.37	1.67	2.22	1.75	1.89	
	Mar. 19, 1940	2.25	1.47	1.96	1.55	1.74	
	Apr. 29, 1940	2.39	1.64	2.25	1.91	1.98	
	May 31, 1940	3.04	1.93	2.37	2.43	2.28	
	Aug. 20, 1941	2.12	1.72	1.84	1.89	1.92	
	Oct. 4, 1941	2.19	1.76	2.09	1.92	1.95	
Field	Oct. 14, 1940	1.81	1.31	1.55	1.27	1.56	
	May 13, 1941	2.17	1.73	1.89	1.54	1.85	
	June 19, 1941	1.93	1.50	1.81	1.81	1.82	
	July 26, 1941	2.09	1.68	1.97	1.95	1.97	
	Sept. 11, 1941	1.75	1.60	1.79	1.54	1.72	

Table 6. The phosphorus content of different clones of white clover at various times during the year, both in the greenhouse and in the field.

Source of sample	Date of sampling	Percentage phosphorus					Av. of 8 clones
		Clone 33(37)	Clone 56(104)	Clone 15(31)	Clone 56(3)		
Greenhouse	Feb. 9, 1940	.409	.262	.289	.341		.332
	Mar. 19, 1940	.338	.254	.311	.343		.315
	Apr. 29, 1940	.379	.259	.326	.346		.320
	May 31, 1940	.440	.305	.354	.346		.350
	Aug. 20, 1941	.395	.246	.273	.308		.290
	Oct. 4, 1941	.285	.259	.300	.266		.274
Field	Oct. 14, 1940	-	.246	.295	.289		.275
	May 13, 1941	.268	.232	.306	.256		.258
	June 19, 1941	.330	.309	.333	.319		.329
	July 26, 1941	.438	.278	.326	.344		.331
	Sept. 11, 1941	.369	.355	.420	.377		.376
	:	:	:	:	:		:

PATHOLOGY

Field Trips

Several survey trips were made during late summer and fall to determine the prevalence and importance of diseases on pasture grasses and legumes. Since circumstances prevented a periodic check on the prevalence of diseases at various times during the growing season, the observations recorded are based on limited data.

Disease Observations

White clover rust *Uromyces trifolii trifolii-repentis* (Liro) Arth. was severe enough to enable differentiation of susceptible and resistant lines of clover among nursery plantings. Under pasture conditions, however, only minor rust infections were noted.

Scattered plants of orchard grass, ryegrass, timothy, and Kentucky bluegrass showed varying degrees of susceptibility to rusts in the nursery. Considerable rust was found on timothy and Kentucky bluegrass under pasture conditions.

Leaf diseases of Kentucky bluegrass caused by Sep-
toria spp. and Helminthosporium vagans Drechs. were severe as usual.

Orchard grass was severely damaged by Scolecotrichum
graminis Fekl., both in nursery and pasture.

Studies on Grass Smuts

During the month of October, a rather intensive pasture survey was made of smuts on Poa pratensis L., Dactylis glomerata L., and Agrostis spp. Infections ranging from less than 1% to almost 20% were estimated. Smutted plants were gathered from 42 pastures representing a wide range of environmental conditions. Samples from the various collections were planted in the greenhouse and observed for progress of disease. Preliminary results showed that the severity of smutting was not decreased by conditions favoring rapid growth of diseased plants.

Periodic examination of Poa pratensis L. collections, both smutted and non-smutted, showed that latent infections hidden for considerable lengths of time gradually appeared under favorable growing conditions. Thus, plants believed to be free of smut were later discovered harboring the parasite. Further studies involving host-parasite relations are in progress.

Microscopic examination of smut spores from diseased plants showed that most of the collections consisted of Ustilago striiformis (Westd.) Niessl, although a few Poa pratensis L. plants were infected with Urocystis
agropyri (Preuss.) Schrt.

Studies on Colletotrichum destructivum O'Gara

Monosporic isolates were obtained from leaves of white clover. Growth of the cultures on potato-dextrose agar indicated that the isolates were gradually losing their ability to sporulate. Accordingly, five cultures were selected for growth in Petri plates on 14 different culture media. Growth and sporulation of each culture on

each medium was compared. Cultures were then transferred from the Petri plates to tubes of the same respective culture medium and grown for six weeks at room temperature. At the end of this time, cultures were transferred back to Petri plates containing potato-dextrose agar.

Profuse sporulation occurred in cultures which had previously failed to sporulate on some of the media. Color and growth type of some of the cultures had changed markedly. In order to determine whether the changes were merely transitory or whether permanent alterations in genetic composition had taken place, cultures were transferred at 7-day intervals to fresh plates of potato-dextrose agar. After four consecutive passages, most of the cultures still retained their altered characteristics, although some tended to revert back to parental types.

Experiments were also carried out to determine the effect of depth of culture medium on growth of C. destructivum. Abundant sporulation occurred in Petri plates containing deep agar. The colonies in these plates were salmon- to flesh colored as a result of the countless spore-masses produced. Poor sporulation and black colonies occurred on plates containing thin layers of culture medium.

The effect on growth of agar poured at various temperatures was also studied. Preliminary results with different batches of potato-dextrose agar showed that variations in temperature at which media were poured exerted some effects on the type of growth of C. destructivum.

Microscopic Observation of Living Stomata

Since many fungi enter plant tissues through stomata, it was deemed of interest to carry out microscopic observations on living leaves being attacked by parasitic organisms. A technique was devised whereby cuttings of Trifolium repens L. were grown in three-fourth inch test tubes containing field soil. After the plants were established and producing new leaves, a single leaflet was selected for observation.

The test tube containing a plant was placed in a holder and manipulated beneath a microscope objective until the desired leaflet lay flat on a slide. A cover glass, hinged to the slide with a piece of cellulose tape, was then laid over the leaflet and the covered area observed through low and high-powered objectives.

Preliminary use of this technique showed that living stomata and germinating spores can be observed continuously or intermittently without injury and, therefore, without alteration.

SUMMARY

COOPERATIVE ACTIVITY

The collaborators together with physiologists and agronomists met at State College, Pa., July 8 and 9, 1941, to consider the general topic, "Effect of Environmental Factors upon Growth and Development of Pasture Plants." Projects were suggested and a committee set up to give further consideration to this important research problem. A mimeographed report of the conference was mailed to each participant.

A regional grassland meeting was held at Durham, N. H., in June. The program was arranged by officers of the New Hampshire Agricultural Experiment Station and of the Northeastern Section of the American Society of Agronomy. One full day was devoted to the presentation of papers and related discussions dealing with grassland agriculture in the Northeast.

COOPERATIVE PROJECTS

The development of another cooperative project between a state station and the Laboratory brings the total of such projects now active to nine. Five of the projects involve breeding one or more of the following pasture plants: colonial bent, Kentucky bluegrass, orchard grass, ryegrass, and white clover. The other four projects are concerned with causes of over-liming injury, investigations of snow mold, anatomy of grass seedlings as influenced by environmental factors, and chemical composition of pasture grasses. Summary statements of activities under these projects may be found in the section of this Annual Report designated for the purpose.

CYTOGENETICS AND BREEDING OF GRASSES

Continued studies of the use of hot water for emasculation of grasses gave results similar to those obtained previously and indicated a very narrow range of critical temperature. The results obtained to date from studies of

seed-set under bag in orchard grass indicate: (1) there is a considerable range in ability to set seed under bag among plants of this species; (2) some of the differences are heritable; (3) the character exhibits such great random variation that it is difficult to distinguish and evaluate the heritable from the non-heritable factors; (4) there is, in general, a reduction accompanying inbreeding in number of seeds per panicle set under bag, much of which can be accounted for by a general reduction in seed-setting ability; and (5) this character is a major obstacle in an inbreeding program. In crosses of male-sterile with male-fertile plants, the character of the F_1 varied both with the female and with the male plants used. The male-sterility of one parent appeared to behave as a simple recessive while that of two other parents behaved in a different manner.

The use of short (3-foot or 6-foot) clonal rows for evaluation of individual plant types was investigated and the results compared well with those obtained from clonal plots.

The breeding behavior of plants of Poa pratensis agreed with results of previous experiments at the Laboratory in indicating a greater amount of sexuality than has been commonly reported for this species. Additional first- and second-generation progeny tests have been established.

The search for heritable characters in orchard grass classifiable in the young plant stage has been continued and many additional types have been isolated. In Sudan grass, extensive studies of the inheritance of a type of leaf spotting have been carried out. An F_2 generation of the hybrid Poa compressa x P. pratensis has been established.

Studies of meiotic behavior in "American" timothy have revealed a high frequency of quadrivalents with occasional sexivalents. Data on inheritance of yellow and albino seedlings obtained from first- and second-generation inbreds are in agreement with the cytological findings.

In Lolium perenne, preliminary evidence indicates that the character of partial asynapsis is conditioned by a single recessive gene plus modifiers. In meiotic behavior the induced autotetraploids of perennial ryegrass resembled plants of orchard grass in quadrivalent and chiasma frequency but differed from plants of orchard grass in having higher frequencies of unpaired chromosomes at metaphase I, of laggards at anaphase I, of unequal

numerical disjunction at AI, and of micronuclei in the quartets. Comparison of frequency of crossing-over in inverted areas of diploid and related autotetraploid plants indicated that inversions probably slightly inhibited randomness of pairing in the autotetraploids. Progenies of the triploid perennial ryegrass plants were found to be $2x$, $2x + 1$, $2x + 1 + 1$, $2x + 1 + 1 + 1$, and $2x + 1 + 1 + 1 + 1$.

Investigations of variations in meiotic behavior among plants of orchard grass have revealed: (1) that there are statistically significant differences among plants in chiasma frequency, quadrivalent frequency, per cent MI sporocytes with unpaired chromosomes, per cent AI sporocytes with lagging and dividing univalents, and frequency of chromosome loss; (2) that these differences are heritable as judged by the progeny test; and (3) that there is a tendency for inbred plants to be more irregular in meiosis than their parents.

CYTOGENETICS AND BREEDING OF LEGUMES

Pseudo-self-compatibility in white clover has been shown to be conditioned by multiple factors, which apparently are independent of the oppositional alleles determining self- and cross-incompatibility. The presence of an S_f gene which conditions self-fertility and which is allelic to the incompatibility alleles has been demonstrated. The S_f allele was dominant to other S alleles in the stigmas, but S_f pollen did not affect other pollen with which it was mixed. In studies of the number of S alleles, two series of plants, involving 26 and 41 alleles, were tested, and of these alleles, 95 per cent and 83 per cent, respectively, were different. Variations in temperature immediately following pollination did not affect seed-set either in compatible or incompatible crosses.

Results obtained under bee cages from plants varying in degree of pseudo-self-compatibility indicated that this character had little effect upon the amount of cross-pollination by the bees except where the most pseudo-self-compatible plant was used.

Inbreeding has been continued in white and Ladino clover and begun in strawberry clover. In white clover, the average vigor of the I_2 lines was estimated at 40 per cent that of their original parents. Clonal plots have

been established from 100 selected white clover plants and from intercrosses of good, medium, and poor plants selected from the plots established in 1938. Collections have been made of Ladino clover from old pastures and plants have been established from these collections.

The inheritance of several adult plant markers is being investigated. Additional studies of the inheritance of HCN have been made by adding the enzyme and the glucoside to the leaves being tested. Indications are that the populations were segregating for factors for the production both of the enzyme and the glucoside. The inheritance of rust resistance in white clover was studied, using inbred, F_1 , and F_2 generations of selected parents and their intercrosses. The results were inconsistent, and no factorial explanation is yet possible.

Studies of meiosis of octoploid plants of white clover and of chromosome number of the progenies of triploid alsike, red, and sweet clover plants have been made.

PHYSIOLOGY AND COMPOSITION OF PASTURE PLANTS

Conditions influencing heading and seed formation were studied with orchard grass and white clover. With orchard grass a period of short days previous to a long photoperiod (16 hours) was essential in initiating floral primordia. Increasing the duration of the periods at short days and low temperature increased the number of heads produced. With white clover a long day was necessary to induce satisfactory head formation, but it was found unnecessary to continue the long-day treatment beyond the pollination stage.

The effect of temperature and daylength on germination of seed and vigor of seedlings was determined with seven species of grass and Ladino clover. With the exception of Sudan grass, which was unaffected by a high temperature, percentages of germination and vigor were less under a temperature of 85-100° F. than under one of 70-85° F. and under a daylength of 16 hours than under one of 9 hours. A study of association of orchard grass and Ladino clover in gravel cultures did not show conclusively the presence or absence of any substance given off by the roots of one which was harmful to the other.

Chemical studies on white clover showed that there were clonal differences in their mineral content. Some clones were consistently higher or lower than others in

calcium or phosphorus under all conditions; others were variable in these respects with temperature having a possible effect. White clover with 64-chromosomes was lower in percentage of fiber than that with 32 chromosomes. Leaves infected with leaf rust were higher in fat, fiber, and nitrogen-free extract and lower in protein than rust-free leaves from the same plant.

Root and rhizome growth and composition studies were made. The yields of underground parts of Kentucky bluegrass in sod showed a variation among 13 clones of from 1,702 to 4,444 pounds per acre in the top three inches of soil. The clones giving the highest yield of roots gave the lowest top yields. Various carbohydrate fractions of the roots and stubble of ryegrass were found to decrease rapidly for about 7 to 10 days after defoliation and thereafter to increase as a result of restorage from new top growth. The latter increase did not occur with plants kept in darkness.

PATHOLOGY

A survey of pastures revealed that several of the more important grasses were severely damaged by leaf diseases.

Greenhouse studies concerning the influence of smuts on the growth and development of Poa pratensis L., Dactylis glomerata L., and Agrostis spp. revealed that rapid growth of diseased plants favored rapid growth of the fungus.

The growth of monosporic isolates of Colletotrichum destructivum O'Gara on various nutrient agars was studied. Preliminary results indicated that cultivation of the fungus on certain media was accompanied by changes in growth type of a more or less permanent nature. The influence of technique on sporulation and growth was also studied.

A method for microscopic observation of living diseased leaves was developed. The technique involved growing the plants in test tubes which were easily manipulated under a microscope.

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- Atwood, S. S. Controlled Self- and Cross-Pollination of Trifolium repens. Jour. Amer. Soc. Agron. 33: 538-545. 1941.
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PROFESSIONAL SOCIETIES DURING 1940

Atwood, S. S. Cytogenetic Basis of Self-Compatibility in Trifolium repens. Genetics 26: 137. 1941.

Myers, W. M., and Hill, Helen D. Variations in Meiotic Behavior Among Plants of the Autotetraploid Dactylis glomerata. Genetics 26: 162. 1941.

PRESENTED - BEFORE PROFESSIONAL SOCIETIES IN 1941

Atwood, S. S. The Multiple Oppositional Alleles Causing Cross-Incompatibility in Trifolium repens. Presented at meetings of the Genetics Society of America. Cold Spring Harbor, Long Island, N. Y. August 27, 28, 29, 1941. (Abstract published in Genetics 27: 129, 1942).

Atwood, S. S. Genetics of Self-Compatibility in Trifolium repens. Presented at meetings of American Society of Agronomy. Washington, D. C. Nov. 12, 13, 14, 1941.

Brittingham, W. H. The Nature and Extent of Variation in Kentucky Bluegrass as Criteria for Apomictic Seed Formation. Presented at meetings of the Genetics Society of America. Dallas, Tex. Dec. 29, 30, 31, 1941. (Abstract published in Genetics 27: 134. 1942).

Garber, R. J. Progress in Pasture Research in the Northeast. Presented at the Grassland Conference. Durham, N. H. June 25, 26, 27, 1941.

Myers, W. M. Natural and Induced Polyploidy in Relation to Breeding Forage Plants. Presented at Meetings of American Society of Agronomy. Washington, D. C. Nov. 12, 13, 14, 1941. (Paper being mimeographed).

Sprague, V. G. Crop-Weather Relationships of Forage Grasses and Legumes. Presented at Meetings of American Society of Agronomy. Washington, D. C. Nov. 12, 13, 14, 1941. (Paper being mimeographed).

MANUSCRIPTS PENDING

Atwood, S. S. Genetics of Pseudo-Self-Compatibility and Its Relation to Cross-Incompatibility in Trifolium repens.

Atwood, S. S. Oppositional Alleles Causing Cross-Incompatibility in Trifolium repens.

- Atwood, S. S. Genetics of Self-Compatibility in Trifolium repens.
- Atwood, S. S., and Garber, R. J. The Evaluation of Individual Plants of White Clover for Yielding Ability in Association with Bluegrass.
- Brittingham, W. H. The Nature and Extent of Variation in Kentucky Bluegrass as Criteria for Type of Seed Formation and Its Practical Implications.
- Garber, R. J., and Chilton, S. J. P. The Occurrence and Inheritance of Certain Leaf "Spots" in Sudan Grass.
- Myers, W. M., and Garber, R. J. The Evaluation of Individual Plants of Pasture Grasses in Association with White Clover.
- Robinson, R. R. Phosphorus Fixation as Affected by Soil Temperature.

Appendix

(The responsibility for compiling each state report was assumed by the collaborator of that state)

PROGRESS REPORT OF STATE STATIONS

CONNECTICUT (STORRS) AGRICULTURAL EXPERIMENT STATION

Title: Alfalfa Experiments.

Leaders: B. A. Brown and R. I. Munsell

a. Response to Soil Treatments. During the late summer of 1941, the second season of the experiment to determine the effects of subsoil treatments, the squares, where the subsoil had been removed, replaced, but not fertilized, had much poorer alfalfa than either those with no disturbance or fertilization below 6 inches or those with subsoil removed, fertilized and replaced. These differences became more marked as the late summer drought retarded growth.

Adding 50 or 100 per cent more Ca PK to the subsoil in 1939 increased the total yields in 1941 by 18 per cent over the fertilization only in the surface 6 inches.

b. Effects of time and frequency of cutting alfalfa under different treatments. The data for 1933-1940 are being prepared for publication. From the results, it appears impossible to cut alfalfa at times which will provide high quality hay and maintain good stands.

c. Effects of amount and depth of applying limestone. The various placements of 1933 resulted in about the same growth of alfalfa resceded in 1939, but the different rates of 1933 had very marked effects as shown by the following data:

<u>Rate of Applying Limestone in 1933</u>	<u>Stand of Alfalfa in 1940 (%)</u>
1000	3
2000	18
4000	55
6000	80

d. The role of minor elements in fertilizing alfalfa. During 1941, light to severe symptoms of boron deficiency were found on 11 of 13 farms in Connecticut. The deficiency was

most apparent on the very sandy Hincley soils. For the first time, the deficiency was apparent on the first cutting. The appearance of symptoms was closely connected with a lack of soil moisture. However, a shortage of soil moisture was sometimes so acute that the alfalfa stopped growing and in such cases, the alfalfa was not always benefited by fertilization with borax. Borax at 20 pounds per acre has been effective for, at least, two years after application.

No deficiencies of other minor elements were noted in 1941.

Title: The Maintenance and Improvement of Pastures.

Leaders: B. A. Brown and R. I. Munsell.

a. The Effects of Fertilizer Treatments on the Soil, the Flora, and the Production as Measured by Grazing. In 1941, the 21st year of quantitative grazing of Cumrings Pastures, surface applied fertilizers caused very large differences in flora, soil reactions, and productions of feed.

Flora - Although it was a so-called "clover" year, native white clover occupied only 2 per cent of the area of the unfertilized plot, but 44 per cent of the optimum minerals (LPK) pasture. Kentucky bluegrass varied from 3 per cent on the unfertilized plot to 74 per cent where minerals (LPK) plus nitrogen at 28 pounds in April, June, and August have been the treatment for 10 years. The LK pasture was the woodiest (35 per cent) and also has the most bare area (13 per cent). Omitting phosphatic fertilizers since 1924 was responsible in 1941 for a 50 per cent reduction in clover and a 60 per cent decrease in bluegrass, but a 120 per cent increase in weeds.

Soil Reactions - The 17 plots in this grazing project have received surface applied limestone at various rates and dates since 1924. Samples of the soil were taken again by 1 inch layers in April 1941. The increases in pH (decreases in acidity) due to the limestone are in table 1.

Table 1. Increases in pH of Soil in 1941 Due to Surface Applied Limestone

Depth (Inches)	: 1 ton : in 1924	: 1 ton in : 1924 & 1929	: 1 ton in : 1924, 1929, & 1939	: 2 tons : in 1932
0-1	: 0.18	: 0.29	: 0.71	: 0.76
1-2	: 0.21	: 0.32	: 0.53	: 0.82
2-3	: 0.19	: 0.42	: 0.45	: 0.79
3-4	: 0.00	: 0.20	: 0.23	: 0.47
4-5	: 0.00	: 0.23	: 0.14	: 0.31
5-6	: 0.00	: 0.17	: 0.09	: 0.27

These and previously published data (S.S.S.A. Proc. 3: 217-221, 1938) show very clearly that the penetrative effects of surface applied limestone are functions of amount applied and lapse of time. Both the increased production of pasturage and the decreased acidity of the soil to, at least, the sixth inch, supply evidence as to the efficiency of limestone applied on the surface of grassland.

Production of pasturage - The 1941 results have not been summarized at this time, but apparently were not much different than during the 9-year period, 1932-1940.

c. The Effects of Various Chemicals on the Soil, on the Botanical Composition of the Sward, and on the Stands and Growth of Kentucky Blue and Rhode Island Bent Grasses. During the 5-year period that this experiment has been in progress, the different sources of N have caused variations in the reactions of the surface inch of soil equivalent to two pH units. Close correlation between pH and exchangeable bases has been found in soil samples from these plots. As a result of the marked changes in the soil reactions, Kentucky bluegrass has almost disappeared from some plots while, under the same treatments, Rhode Island bent grass, although not thrifty, has nearly perfect stands.

At either 84 or 168 pounds per acre annually; a pound of N has increased total yields of both bent and blue grasses by about 10 pounds of dry matter or roughly equivalent to 6 pounds of digestible nutrients.

d. The adaptability of Varieties and Species of Grasses and Clovers for Pastures. Birdsfoot Trefoil - New York strains of this species have been seeded on untilled pastures and in mixtures on tilled fields, but very little trefoil has become established in either situation.

Strains of Common Grasses - The data, from the most recent tests of many strains of grasses in pure culture and mowed three times per season have not been summarized at this time (December 30, 1941).

Ladino or Kent Clover-Grass Mixtures Lawn Mowed when 4" to 1" - In the sixth consecutive season of lawnmowing when 4" to 1" (average eight cuttings per season), Ladino was superior to Kent clover with each of nine grasses and averaged about 25 per cent more dry matter. In seven of nine cases, seeding Ladino with a grass in 1936 resulted in larger yields in 1941 than applying nitrogen at 28 pounds per acre

three times during the season to the grasses alone. The seasonal distribution has also been better on the Ladino plots. In September 1941, Ladino occupied 27 per cent of its plots, while Kent averaged 15 per cent.

During the six years, four Ladino-grass mixtures have averaged to produce a total of 16,612 pounds of dry matter per acre. Analyses for three years showed this dry matter to contain 4.15 per cent N, 0.95 per cent P_2O_5 , and 2.01 per cent K_2O or, respectively, 689, 158, and 334 pounds of those fertilizer constituents.

Management of Ladino-grass Mixtures - Ten different systems of cutting Ladino-timothy and Ladino-orchard grass mixtures (on triplicated 75 by 15 foot plots) have been under trial for about two and one-half seasons. The number of cuttings each season, the average stands of Ladino in 1941, and the 1939, 1940, and 1941 total yields of dry matter are given in table 2.

Table 2. Management of Ladino-Grass Mixtures.

Cutting Systems When: To		Stand of:				Dry Matter			
		Ladino	Number of			(Pounds Per Acre)			
		Oct. 8, 1941	1939*	1940	1941	1939*	1940	1941	Totals
Timothy Section									
6" : 2"		75	3	5	6	1766	2637	4603	9006
6" : 4"		50	4	7	7	592	2844	4564	8000
8" : 2"		53	2	3	4	1377	2922	4141	8940
8" : 4"		33	2	5	5	574	2603	4560	7737
10" : 2"		70	1	3	3	1456	2878	4386	8720
10" : 4"		65	1	3	4	948	3054	4774	8776
8" : 4" (0 before 6/15)		65	2	5	3	630	2723	5670	9023
6" : 2" (0 before 6/15)		55	3	3	4	1842	2299	6684	10825
8" : 4" (0 after 9/1)		68	1	4	4	158	2702	4101	6961
8" : 4" (0 after 10/1)		68	2	5	4	657	2925	4122	7704
Orchard Grass Section									
6" : 2"		77	3	5	6	1972	2936	4337	9245
6" : 4"		72	4	7	7	694	3370	4325	8389
8" : 2"		70	2	3	4	2227	3025	4455	9707
8" : 4"		67	2	5	5	735	3288	4317	8340
10" : 2"		70	1	3	3	1562	3305	3891	8758
10" : 4"		48	1	3	4	896	3413	5473	9782
8" : 4" (0 before 6/1)		70	2	5	4	602	3235	4843	8680
6" : 2" (0 before 6/1)		45	3	4	4	1775	2679	5009	9463
8" : 4" (0 after 9/1)		52	1	4	4	96	3027	4029	7152
8" : 4" (0 after 10/1)		55	2	5	4	615	3623	3791	8029

*Seeded on May 5 with oats, which were mowed June 29.

The first cutting of Ladino and grasses was on Aug. 7.

In 1940, there was a tendency for systems with less frequent and higher cuttings to have more Ladino, but that trend appears to have been reversed in 1941. This change may have been due to the greater prevalence of the grasses in 1941 than in 1940. Regardless of height of setting the mower, the new growth of Ladino starts from the prostrate stems, which are at the surface of the ground, but any remains of the leaf blades of grasses are pushed upward from the growing point. Therefore, in mixed stands, setting the mower to cut high, favors grasses over Ladino.

For the systems where the mower was set to cut 2" above the ground, the more frequent the cutting, the more prevalent the Ladino. This also may reflect the great differences in the habits of growth of Ladino and grasses. Ladino is a low growing species with very quick recovery after defoliation. The reverse holds for the grasses. Thus, under the extremely competitive conditions existing in Ladino-grass mixtures, Ladino is favored by more frequent mowing.

As for the total yields of dry matter, there is a distinct tendency for the less frequent and higher (above ground) systems to be superior to the more frequently and closely mown ones. In the timothy mixtures, the two systems where the first mowing is deferred until June 15 had very large yields in 1941. This was due to the hay-like growth in the first cutting. Making no cuttings after September 1 has been a great handicap to that system although, because of very dry weather in September 1941, fall yields were very low in most cases.

Because of the changes in results which have already occurred in this experiment, guessing as to the final outcome appears to be a very hazardous speculation.

f. Causes of Fluctuations in the Prevalence of White Clover. In Connecticut, 1941 was a so-called "clover" year. Both red and white clovers appeared in considerable amounts on areas where scarcely any had been seen in recent seasons. It is, therefore, particularly interesting to check on weather, fertility, and managerial conditions, which might affect the prevalence of clovers.

Weather at Storrs:

1940 - Fifth coldest January but no extremes; cold, wet spring and early summer; very dry from July through October.

1941 - January was unusually cold; February had second lowest snowfall on record (1") and soil was bare most of month; March was sixth coldest and had double normal snowfall; April was second warmest and very dry (only 35% normal rain); May, June, and July were warm and above average in precipitation; August, September, and October were very dry.

Because of the dry, warm April and early May in 1941, grasses started and grew slowly and this, no doubt, favored any clovers already established and possibly the establishment of more clover from seed.

Other Environmental Conditions - In two experiments at Storrs, particular attention is given to causes of clover prevalence. In one, where the plots are lawnmowed every two weeks and where 15 different fertilizer treatments and other conditions are under test, the average increases in clover from October 4, 1940, to September 10, 1941, were:

Kent	- from 18 to 46 or 150 per cent
Dutch	- from 13 to 18 or 35 per cent
Ladino	- from 12 to 21 or 75 per cent

There were no decreases, regardless of fertilization. The greatest actual changes occurred under fertilizer treatments which had stimulated the most clover before 1941. So far, clovers have not responded to the minor elements B, Mn, Cu, or Zn. Cutting to 0.5" or 1.0" above the soil or whether the accompanying grass was Kentucky bluegrass or Rhode Island bent grass made little difference in the prevalence of any of these three clovers.

In the second experiment, the fields have been mowed for hay in June and grazed in late summer and fall. Of the over 200 plots and 100 different fertilizer treatments on these fields, about half had more clover in 1941 than in 1940. However, most of the treatments which had favored clover had increases and, as in the first experiment, the more clover present in 1940, the larger the actual increases in 1941 unless a favorable change had been made in fertilization.

It has been interesting to note that for many years under this type of management, considered by some as unfavorable to white clover, 40 to 60% of the area in plots liberally treated with Ca, P, and especially K, has been occupied by native white clover. This clover is not the low growing type.

Title: Studies on Physical and Chemical Properties of Soils.

Leaders: B. A. Brown and R. I. Munsoll

b. Physical and Chemical Studies of Soils. Over a 3-year period, disking in versus surface applications of limestone, superphosphate and muriate of potash on tilled seeded plots resulted in some chemical differences in the various layers of the soil, but not in root development or yields of two grass-legume mixtures.

Grass Silage - No formal experiments were conducted on this topic the past year. Thinking it might be of interest, however, to see what yields may be expected from several possible silage crops under moderate fertilization on the Station farm at Storrs, the following table has been prepared:

Table 3. Yields of some crops for silage*

	Pounds per acre		
	Dry Matter	Protein	Digestible Nutrients**
Alfalfa - first cutting	3400	620	1880
second cutting	2100	460	1161
total	5500	1080	3041
Red clover - first year after seeding	3300	430	1890
Timothy - next year after red clover	2900	175	1690
Ladino (65%) & orchard grass (35%)	3700	740	2400
Millo (Japanese)	6000	360	3280
Sudan grass	5000	280	2900
Oats	2900	270	1530
Kentucky bluegrass (N at 84 lbs. annually)	2800	650	1960
Permanent pasture (LP fertilization)	2800	672	1820
Soybeans	4300	800	2370
Corn	7400	550	4900

*These are average yields obtained on moderately fertilized Charlton fine sandy loam soil on the Station farm at Storrs.

**The percentages of digestible nutrients used to determine the values in this column were estimated, using as guides Henry & Morrison's tables & Woodman's (England) results on the digestibility of young grasses.

DELAWARE AGRICULTURAL EXPERIMENT STATION

Title: Lespedeza Selections for Pasture Types.

Leaders: G. L. Schuster and C. E. Phillips.

Tests with the strains of Korean lespedeza during the last year have been limited by the drought conditions. This has interfered with the collection of yield data but has offered opportunity to observe drought resistance of the strains.

The selections were seeded in small plots in a pasture last spring for observation under actual grazing conditions. It is hoped that from these tests final selections may be made.

Title: Selection and Breeding of Trifolium Species.

Leaders: J. M. Watkins and C. E. Phillips.

The selection and breeding of Trifolium species has been continued with major emphasis being given to white clover and crimson clover. A large number of the white clover strains carried in nursery tests were eliminated when the plots were transferred to another location. Twenty of the most promising strains are being tested in competition with Kentucky bluegrass.

Seed-setting studies in white clover have been conducted along two lines: (1) the effect of clipping treatments. Plots clipped only on May 15 were superior to the other clipping treatments. (2) Seed-setting as a heritable characteristic. The best strain produced more than four bushels per acre. It is apparent that competition of the common grasses is a limiting factor in clover seed production here.

Replicated plots of crimson clover and red clover were seeded in 1941 for observations and yield tests. A large number of crimson clover selections made in the summer were included in nursery plots for observation and testing.

Title: Evaluating Ranges for Poultry.

Leaders: W. C. Skoglund and J. M. Watkins.

A project for evaluating ranges for poultry was approved in 1940. It has as its objectives: (1) evaluating

type of herbage for poultry ranges as to palatability and durability, (2) determining the influence of various ranges on feed savings, and (3) determining the effect of ranges upon the following: (a) increase in live weight of the growing birds, (b) general health and condition of the flock, and (c) subsequent livability and egg production in the laying house.

The experiment consists of five plots, 1/5 acre each, with the following treatments:

- A. Check (bare ground).
- B. Mixture of Kentucky bluegrass, redtop, ryegrass, and timothy.
- C. Mixture of Ladino clover and White Dutch clover.
- D. Mixture of B and C.
- E. Mixture of alfalfa and red clover.

Birds grown on these plots are being compared with those in total confinement.

Plot C stood up best during the summer and appeared to be more palatable than the other ranges.

Title: Pasture Management and Milk Production.

Leaders: C. E. Phillips and A. E. Tomhave.

The season of 1941 was extremely dry and the growth of pasture grass was, therefore, much less than normal. Clippings were made from caged areas and the amount of grass grazed by the cows was calculated by the "difference" method. The Ladino clover plot produced 64% more green grass (eaten by cows) than the average of all other mixtures (45 pounds green grass per day for the period grazed).

All the data have not been tabulated, but it can be said that pasture alone did not maintain a satisfactory rate of milk production.

MAINE AGRICULTURAL EXPERIMENT STATION

Title: Grassland Studies.

Leaders: D. S. Fink

Native Pasture: A detail experiment dealing with the fertilizer maintenance requirements of an excellent native

pasture is being continued. Preliminary information indicates that about 60 pounds each of N, P_2O_5 , and K_2O per acre should be applied annually to maintain an excellent native pasture in excellent production.

Ladino Clover. Seeding trials with Ladino clover and timothy, reported in the 1939 Annual Report of the Maine Agricultural Experiment Station, showing that two pounds of Ladino clover and seven pounds timothy per acre produces a most excellent stand for pasture, hay, or grass silage, have been substantiated under numerous farm conditions.

Ladino clover has become well-established over a 3-year period, through merely broadcasting Ladino clover seed and fertilizer on top of the sod of an old "run out" permanent pasture (paddock 4, Highmoor Farm). The requirement for success with this practice seems to be one of having Ladino clover seed present in the soil during the period of soil fertility improvement.

Observations indicate that a grass superior to timothy in rapidity of after-growth is needed in association with Ladino clover, and to this end a grass species-Ladino clover trial is under way at Highmoor Farm. Selected strains of various grasses were furnished for this study by the Soil Conservation Service.

Strawberry Clover. An excellent stand of strawberry clover and reed canary grass was established in paddock 5 this past summer, and information will be gained as to the adaptability and usefulness of this association.

Grass Silage. A study was made of the losses in total weight and dry matter for two methods of preserving grass for silage and the data obtained are given in table 1. The study comprised a comparison of:

Silo 1 - First crop Ladino clover-timothy cut in directly from the field with 50 pounds of molasses added per ton of fresh material.

Silo 2 - Second crop Ladino clover-timothy cut in partially air-dried with five gallons of dilute phosphoric acid (1 gallon of 75% food-grade phosphoric acid to 4 gallons of water) added per ton of partially air-dry material.

The losses sustained in total weight for the two methods of preservation were 32.4% for silo 1 and 5.5% for silo 2.

The losses in total dry matter were 19.4% in the case of silo 1, and 7.3% in the case of silo 2.

The silage from both silos 1 and 2 was of high quality, free from butyric acid, and of good color. Except for the immediate surface, both silages maintained a consistent pH value of 4.0 ± 0.1 throughout.

Table 1. The percentage losses in total weight, spoilage, & dry matter for two different methods of silage preservation, together with the pounds of each silage to give one pound of dry matter. (Ladino clover-timothy was the source of silage material).

	: Silo 1	: Silo 2
	: (22% dry	: (33% dry
	: matter with:	: matter with:
	: molasses)	: H_3PO_4)
Total lbs. of material, including preservative weighed in	: 113,924	: 63,559
Total lbs. of silage, including spoilage, weighed out	: 77,018	: 60,037
Lbs. loss in total wt. of material put in:	36,906	: 3,522
Percentage loss in total wt. of material put in	: 32.4:	: 5.5
Total lbs. spoiled silage	: 2,436	: 1,280
Percentage loss of material due to spoilage	: 2.1:	: 2.0
*% dry matter content, including preservative, of material in	: 21.8:	: 33.1
Total lbs. dry matter in	: 24,903.8:	: 21,037.0
*% dry matter content of silage out	: 26.06:	: 32.5
Total lbs. of dry matter out	: 20,070.9:	: 19,512.0
Lbs. loss in total dry matter put in	: 4,832.9:	: 1,525.0
Percentage loss in total dry matter put in	: 19.4:	: 7.3
Cubic feet occupied by silage at start of feeding	: 1,577	: 1,394
Average wt. per cubic foot, lbs.	: 48.8:	: 43.1
Lbs. silage to give 1 lb. of dry matter:	: 3.84:	: 3.08

*Dry matter determinations of material in & silage out were made on composite samples of same material. During filling, 3 bags full of the silage were buried following approximately every 3 tons of fresh material (silo 1) & every ton and half of air-dry material (silo 2). Dry matter determinations for a given level in each silo were weighted according to silage represented by each bag. A total of 54 bags were buried in silo 1 and 60 bags in silo 2.

MARYLAND AGRICULTURAL EXPERIMENT STATION

Title: Methods of Improving Permanent Pastures on the Several Soil Provinces in Maryland.

Leader: W. B. Kemp.

Severe drought throughout most of the growing season of 1941 killed out all spring seedings of both grass and clovers, while August seedings either did not come up or emerged so late in the fall that they are not likely to survive the winter. Therefore, no report is made on new seedings.

So much of native wild white clover has come into all plots which are planted to white clovers from different sources that comparison of sources is impossible.

As a part of the studies on the effects of fertilizers and treatment on pastures and in cooperation with the Extension Service, detailed records of treatment for the past five years have been obtained on many pastures in different parts of the state. Some pastures that have been limed and fertilized and others that have received no fertilization have been chosen for yield studies. At least two cages per field have been kept in these pastures during the past summer. From time to time during the season the grass under these cages has been clipped along with that equal uncaged areas and the cages have been moved to new locations in the fields. These clippings have been dried and weighed and comparisons have been made on the basis of material dried to 12% of moisture.

On some pastures complete records are not available, either because cages were destroyed or for some other reason. The general results are presented in the following tables for those pastures where full records were taken. Treatments varied widely from one pasture to another. In general, treatments were much more liberal on the Piedmont soils (Chester, Manor, Montalto) than on either the limestone soils (Hagerstown) or on the mountain soils (Dekalb, Meigs).

The results are shown in table 1.

Some of the fields in table 1 that are classified as untreated have had an occasional application of either manure or lime, but no commercial fertilizer within the past five years.

With few exceptions, fertilizer treatments have been highly profitable even though some of the fertilizer treatments have been light and others heavy, and the fertilizer composition has varied widely.

On the Chester, Manor, or Montalto soils of the Piedmont plateau records have been taken on other pastures as well as those consisting of bluegrass and white clover. In table 2 these results are presented. The conditions surrounding these different pastures are not sufficiently uniform for the yield differences to be considered as significant. However, the figures provide an opportunity to determine what some pastures of the different types produced in the year 1941.

Table 1. Comparison of Yields and Plant Populations between Treated and Untreated Bluegrass Pastures on Different Soil Types in Maryland for 1941.

Soil type	Treatment	Flds.	Ph.	Yld. 12% moisture		Composition	
				Total	Consumed	Perennial grasses	Legumes
Dekalb or Meigs	Treated	5	6.0	3032	2949	44.2	17.0
	Not treated	3	5.2	1281	1081	30.5	8.5
	Difference		0.8	1751	1868	13.7	8.5
Hagerstown	Treated	2	6.6	3283	3159	65.6	19.0
	Not treated	2	6.7	2290	2129	57.8	16.8
	Difference		0.1	993	980	8.1	2.2
Chester, Manor, or Montalto	Treated	3	6.5	5116	4930	60.7	17.0
	Not treated	4	5.4	2036	1823	50.1	12.3
	Difference		1.1	3080	3107	10.6	4.7

Table 2. Yields from Pastures of Three Different Types in the Piedmont Area of Maryland in 1941

Pasture type	Flds.	Ph.	Total yld. 12% moisture		Av. Composition	
			Average	Highest	Perennial grasses	Legumes
Orchard grass or orchard & lespedeza	2	6.4	6786	8688	66.4	15.7
Ladino	2	6.3	6444	7741	18.3	77.2
Bluegrass-clover	3	6.5	5116	6796	60.7	17.0

Pastures of all types were exceedingly poor in the late fall.

MASSACHUSETTS AGRICULTURAL EXPERIMENT STATION

Title: The Improvement of Perennial Pasture Species.

Leader: W. G. Colby.

Experiments are being conducted at Amherst with pasture seeding mixtures for the purpose of studying improved strains of grasses and legumes under actual grazing conditions. Three series of plots were laid out in 1940, on land which had been brought to a high state of fertility through the liberal use of lime, manure, and commercial fertilizer. Two series (I and II) of 19 plots each were seeded August 23, 1940, and a third series (III) of 13 plots was seeded April 18, 1941. The same mixtures were included in each series insofar as was possible. In several instances, due to limited seed supplies, certain mixtures occurred on only one or two of the three series.

Another object of the experiment was to compare a system of hay-pasture management with pasturing alone and to test summer seeding of pasture mixtures against spring seeding. During 1941, Series I was subjected to four periods of intensive grazing by a small herd of dairy cows. The first grazing period was in May, the second was in July, the third was in August, and the fourth was in October. Series II was first cut for hay before being subjected to three periods of grazing. The three grazing periods for Series II coincided with the last three grazing periods of Series I. The spring seeded series (III) was grazed only lightly at the same time as Series II. The following observations and results deserve mention:

1. Some grass and meadow fescue (Svalof's early) showed the most promise as being desirable companion grasses for Ladino clover. The cutting of an early hay crop followed by several periods of intensive grazing appeared to be the most desirable way of utilizing these grasses.
2. Hay types of orchard grass (Scandia and Commercial) as well as the less vigorous pasture types (S26 and S143) did not combine well with Ladino clover. The orchard grass, irrespective of how it was managed, tended to crowd out the clover even during the first season. This occurs partly because orchard grass grows vigorously throughout the season and partly because it produces

tussocks or bunches. Animals grazing on Ladino clover mixtures of this grass tended to graze the clover growing between the bunches of orchard grass much more closely than they did the clumps of grass. This occurred even though the orchard grass was kept in a young, active, vegetative growth stage at all times. As a result of preferential grazing, the stand of orchard grass continually improved and the stand of clover deteriorated.

These observations may explain why in Massachusetts orchard grass in Ladino clover seeding mixtures, invariably crowds out Ladino clover, completely, after three or four years and results in a pure stand of orchard grass.

The most promising mixtures using orchard grass were those which included alfalfa and which were cut for hay before being grazed. For this purpose, the later maturing pasture strains (S26 and S143) were much superior to the hay strains. There is a real need for a hay strain which will mature from a week to 10 days later than do any strains now available commercially.

3. The hay-pasture system of management rather than pasture alone appears to have excellent possibilities as a way of utilizing a number of these early maturing grasses (brome, meadow fescue, orchard) not only in producing a good early hay crop but also in providing excellent feed for midsummer grazing. In these experiments, about two tons of dry hay were cut to the acre in the middle of June, followed roughly by three quarters of a ton of dry herbage as grazing material the latter part of July, about the same quantity again late in August and by another half ton early in October.
4. Observations on palatability indicated that timothy ranked first among the grasses followed in order by brome grass, meadow fescue, redtop, orchard grass, and tall fescue (Alta strain). Alfalfa, red clover, and alsike, although quite palatable as young plants, became less palatable than Ladino clover as the plants became older and developed woody stems. The woody, unpalatable stem growth of alfalfa is a serious handicap to the use of this plant for grazing purposes.
5. A good stand of alfalfa was obtained in all of the hay-pasture mixtures (Series I) but only weak stands were obtained when an early period of grazing took the place of a crop of hay (Series II). Apparently alfalfa must be allowed to become well-established before grazing is begun.

6. Birdsfoot trefoil, under the conditions of these experiments, showed no promise whatsoever.

Table 1. Hay and grazing yields from hay-pasture seeding mixtures (Series I). Amherst 1941.

Seeding mixture	Seed:		Pounds of dry matter per acre				
	ing :						
	ratio :						
	lbs. :		Hay	Grazed herbage			Total
	per :	Date		July	Aug.	Oct.	
	acre :	cut	Yld.	20	20	10	
1. Meadow Fescue (Alta)	: 15	: June 6	: 3800	: 2990	: 1520	: 720	: 9030
Ladino	: 3	:	:	:	:	:	:
2. Meadow Fescue (Svalof)	: 15	: June 6	: 4310	: 1670	: 1420	: 870	: 8270
Ladino	: 3	:	:	:	:	:	:
3. Orchard Grass S143	: 10	: June 17	: 3190	: 1890	: 1520	: 650	: 7250
Ladino	: 3	:	:	:	:	:	:
4. Orchard Grass (Scandia)	: 10	: June 17	: 4100	: 1670	: 1220	: 940	: 7930
Ladino	: 3	:	:	:	:	:	:
5. Brome Grass	: 15	: June 11	: 3750	: 2030	: 1450	: 940	: 8170
Ladino	: 3	:	:	:	:	:	:
6. Orchard Grass S26	: 15	: June 17	: 3690	: 2030	: 2030	: 870	: 8620
Alfalfa	: 10	:	:	:	:	:	:
Ladino	: 3	:	:	:	:	:	:
7. Orchard Grass (Scandia)	: 5	: June 17	: 4220	: 1880	: 1670	: 870	: 8640
Alfalfa	: 10	:	:	:	:	:	:
Ladino	: 3	:	:	:	:	:	:
8. Brome Grass	: 10	: June 11	: 3800	: 2100	: 1820	: 800	: 8520
Alfalfa	: 10	:	:	:	:	:	:
Ladino	: 3	:	:	:	:	:	:
9. Meadow Fescue (Alta)	: 10	: June 11	: 4710	: 2100	: 1950	: 720	: 9480
Alfalfa	: 10	:	:	:	:	:	:
Ladino	: 3	:	:	:	:	:	:
10. Orchard Grass S143	: 10	: June 17	: 3520	: 1740	: 1520	: 720	: 7500
Alfalfa	: 12	:	:	:	:	:	:

Table 1. (Continued)

Seeding mixture	:Seed-:						
	:ing	: Pounds of dry matter per acre					
	:rate						
	:lbs.	: Hay	: Grazed herbage	:Total			
	:per	: Date	: July	: Aug.	: Oct.		
	:acre	: cut	: Yld.	: 20	: 20	: 10	
11. Red clover	: 4	: June 17	: 5440	: 1300	: 1600	: 720	: 9060
Alsike	: 2						
Ladino	: 1						
Alfalfa	: 5						
Timothy	: 2						
Orchard Grass	: 6						
12. Red Clover	: 6	: July 3	: 6600	: -	: 1300	: 430	: 8330
Alsike	: 4						
Ladino	: 2						
Timothy	: 3						
Red Top	: 2						
Kentucky Blue	: 3						
13. Red Clover	: 3	: July 3	: 6580	: -	: 720	: 360	: 7660
Alsike	: 6						
Ladino	: 3						
Timothy	: 3						
Red Top	: 2						
Kentucky Blue	: 3						
14. Meadow Fescue (Svalof)	: 10	: June 6	: 3520	: 1740	: 1600	: 650	: 7510
Alsike	: 3						
Red Clover	: 5						
15. Red Top	: 10	: July 3	: 7510	: -	: 870	: 220	: 8600
Red Clover	: 6						
Alsike	: 3						
16. Timothy (Cornell 4038)	: 12	: July 3	: 5800	: -	: 650	: 650	: 7100
Red Clover (Mammoth)	: 5						
17. Timothy (Cornell 4038)	: 12	: July 3	: 5990	: -	: 870	: 430	: 7290
Red Clover (Mammoth)	: 5						
Birdsfoot Trefoil	: 6						
18. Timothy (Milton)	: 10	: July 3	: 6990	: -	: 650	: 570	: 8210
Alsike	: 3						
Red Clover	: 5						
Birdsfoot Trefoil	: 6						
19. Meadow Fescue (Svalof)	: 10	: June 11	: 4190	: 1890	: 1220	: 650	: 7950
Red Clover	: 6						
Alsike	: 3						
Birdsfoot Trefoil	: 6						

NEW HAMPSHIRE AGRICULTURAL EXPERIMENT STATION

Title: A Study of Pasture Species Under New Hampshire Conditions.

Leader: Ford S. Prince, Leroy J. Higgins, and Paul T. Blood.

Work progressed during the year on selection and breeding of timothy, red clover, and white clover strains. In addition to these three species on which we have been concentrating our attention, several other species are being studied as to growth habits, persistence in pastures, ability to recover after pasturing or clipping and like factors which are of economic importance. In these studies are included meadow fox-tail, ryegrass, orchard grass, Canada bluegrass, some of the fescues, yellow trefoil and Birdsfoot trefoil.

Timothy. Plants representing two types of timothy were selected during the autumn of 1940. One of these was a vigorous, late-flowering, hay type; the other a shorter, but very prolific, semi-decumbent type which we believe may resist the effect of grazing animals to a greater degree than the more erect strains. Parent sources of these strains were drawn from plants in our nursery, the hay type being represented by "native" New Hampshire timothy from wild locations, and from certain Scotch, Ohio, and Canadian strains, while the pasture type was derived almost wholly from "native" stock secured by picking seeds from old pastures, hedgerows, roadsides, never more than one seed from each plant. (Of 22 plants used, 17 were "native" and five were represented by Canadian O.A.C. pasture type).

The plants were broken up and propagated clonally, in rows, the hay type being grown in an isolated location in Greenland, New Hampshire, and the pasture type on the college farm. The hay type was represented in the field by 40 plants, divided into 25 clones, while the pasture type represented 22 mother plants. In addition to the field work, one cutting from each plant was placed in the greenhouse. These were carried along and studied at intervals for different characteristics. It was found, for example, that the number of culms per plant just before heading averaged 35 for the hay type and 69 for the pasture sort. The pasture type, too, was characterized by having many more basal leaves than the hay type, but this characteristic was not measured.

Difficulty was experienced in bringing the plants into head in mid-winter until the photoperiod was lengthened. This

was done merely by arranging ordinary electric lights over the greenhouse bench, and extending the natural lighting period. Our conclusion here was that although it was not necessary to allow the lights to burn all night to force the plants into head, still it did no harm to do so, and oftentimes when inconvenient to turn them off they were allowed to run all night long. During the blooming process, the two plant types were separated and placed in different greenhouses.

Flowering started in February and a small crop of seed was harvested from these greenhouse plants in April. Nearly all of the seed produced in the greenhouse was planted in long, narrow plots in the nursery in August. These plots will be divided next year and harvested at different times and at different clipping heights to note the comparative yields, persistence, and other factors under various types of clipping.

Considerable seed was harvested from the field locations and we will be prepared to distribute small quantities of seed of both strains in the spring of 1942. Early in 1942 we plan to make rather extensive planting of both types for field testing.

In addition to the above work with timothy, we now have in the greenhouse about 20 plants each of timothy from four sources: (1) from an outstanding "Milton" plant; (2) from a cross made in 1939 between two pasture types; (3 and 4) from two families which were selected in 1937 and which have been grown in red rows. The latter two strains are from native sources and appear to have somewhat greater recovery power after clipping than most of the other lots under observation.

These strains are being selfed this winter by bringing them into flower at different times by regulating the photoperiod in the greenhouse.

Red Clover. During the winter of 1940-41, reciprocal crosses were made among 10 families of red clover that had previously exhibited in the field a perennial tendency. Seeds from these crosses were planted and these are again being hand-worked in the greenhouse to fix the perennial tendency, if possible. Furthermore, plants from each cross are now growing in the nursery.

Field-grown progeny of these original 12 plants are growing in duplicate plots in the nursery. Although the amount of seed at our disposal was small, duplicate plots are being grown at different potash levels, since we have found in field trials that abundant potash tends to favor longevity in red clover.

More material with a possible perennial tendency was gathered in 1940 and this is now also being grown in the nursery, having been started in the greenhouse in the spring of 1941 and later transplanted.

Wild White and Ladino Clover. The F_1 generation which represents crosses between Ladino and native wild white, Ladino and New Zealand, and Ladino and S-100 was propagated during the summer, the seed being first germinated in the Seed Laboratory, pricked into flats, and later set in the nursery.

Our technique with respect to clovers, and more especially the handling of hard seeds, is far from perfect. Out of about 1,000 individual seeds from the various crosses, slightly less than 100 plants were secured. Fortunately, these represented all of the crosses which were made in our bee-proof greenhouse in 1940.

From those plants that we did secure and which are now growing in the nursery, many appear to represent the form that we desire, that is, a very leafy but somewhat larger plant than either wild white, New Zealand, or S-100 clover. In other words, they have the required leafiness but still lack the size that a strain of white clover should have to compete with tall grasses, a point which is one of the favorable attributes of Ladino clover.

Cuttings of 15 of these F_1 's have been potted and placed in the greenhouse. An equal number of Ladino cuttings taken from an old seeding on the farm of Francis Peaslee near Pittsfield have been secured and these are to be used for purposes of backcrossing. Backcrossing is now being accomplished in the greenhouse and the plan is to continue this method of breeding in the hope of developing a much more leafy strain of clover similar in growth habits to Ladino.

During the summer, work was continued on the selection of a large strain of native wild white clover by choosing some of the outstanding plants in our 3-year old nursery and isolating

them under a screen. This screen was so arranged that bees could be introduced to perform the necessary pollination and from the plants so isolated we have secured a very small amount of seed which will be sown in 1942, and from which we hope to multiply our stock.

Other Species and Strains. Observations are being made on many other species and strains in the nursery and in the greenhouse. In the autumn of 1941 cuttings were taken from orchard grass plants that have been growing in the locality of Durham for 20 years or more and these have been placed in the greenhouse to determine the possibilities of producing seed.

From an original planting of isolated smooth brome grass plants, seven plants with a creeping tendency have been isolated and propagated clonally for seed production purposes.

Ryegrass seed of one of the improved Welsh strains was picked from a farm near Jefferson in 1940. This was propagated and the plants are now growing in the nursery. The parent plants had survived two winters in their Jefferson habitat, 130 miles north of Durham.

In addition, we have a large number of plants as well as red rows of different species and strains in the nursery from which we hope to draw some definite conclusions or secure breeding material later on.

Pasture Trials of Species. New seedings were made in the spring of 1941 on the Angell farm in the town of Lee on a Merrimack loamy sand soil involving some of the larger grasses, each seeded alone with Ladino clover. Seeds for this test were supplied by the Soil Conservation Service and include creeping brome, non-creeping brome, orchard grass, Victoria perennial rye, creeping red fescue, and meadow foxtail. These were seeded in rather large plots and will be included in Mr. Angell's regular system of rotation pasture management.

The worst drought in 45 years was experienced in Durham in 1941. None of the months during the growing season had normal rainfall and during two of these months less than one inch of rain fell, this in scattered, small showers that evaporated almost immediately. The season was also one of high winds which induced excessive evaporation.

Because of the abnormal weather, pasture species counts in previously established plots in the O'Kane and Angell pastures were not made. These plots are being continued, however. Counts made in the autumn of 1940 were included in the report for that year.

Reseeding on Old Pasture Sods. During the autumn of 1940 and the spring of 1941, experimental seedings of Ladino clover were made on top of old pasture sods in the towns of Durham, Fremont, and Hollis. In some instances Kentucky bluegrass and redtop were included in the seedings and various fertilizers were applied to portions of the plots to note differences in germination and growth. Ladino clover was chosen since it is possible to identify the plants and check the response to better advantage than if a smaller strain of white clover were used.

Seedings were made about November 1, 1940, and April 1, 1941. Some improvement in the sod was noted from the November seeding but none was noticeable from the April trials. Here, again, the effect of the drought was apparent.

Title: An Experiment in Top-Dressing Old Pasture Lands with Lime and Fertilizer.

Leader: Ford S. Prince, and Paul T. Blood.

History and Previous Work. (N. H. Bulletin 320). This experiment was continued in two locations with certain modifications in treatment. Fundamentally, the trials are quite similar, although one is located in eastern New Hampshire, while the other is situated in the Connecticut Valley area in the western part of the state. Modifications during the year involve delaying the applications of nitrogen on certain plots, some alteration in other fertilizer treatments, and noting differences in vegetative cover.

The Livingston pasture (Connecticut Valley) is especially responsive to fertilizer changes. Continued use of nitrogen alone even under close grazing will eliminate wild white clover, whereas changing to a complete fertilizer or to a fertilizer containing potash and phosphoric acid will cause the reappearance of clover within a month of its application, if such application is made in the spring.

Yield records from both pastures were taken in 1941, but due to drought, yields were very low. Fertilizer treatments were last applied in the spring of 1941.

Studies on Old Pasture Soils. Although it had been our plan to discontinue work on the Seavey pasture (eastern New Hampshire) this study was continued during 1941 in order to conduct soil studies on certain treatments in both pastures which have been top-dressed over a long period.

During the autumn of 1941, core samples were taken on both pastures to determine changes in soil structure and organic matter content due to treatment. Yields have varied significantly through the years and we now desire to learn to what extent soil conditions have been changed either directly by treatment or indirectly because of increased root systems of the crops grown there.

Ten core samples have been secured from each plot and these are being analyzed for aggregation of particles in the 0-2, 2-4, and 4-6 inch horizons. Upon the completion of the work on aggregation, organic matter determinations will be made on the samples, by levels, to see what correlation exists between aggregation, organic matter, and yields. This work is now in progress in the laboratory and a report on aggregation and organic content should be ready in 1942.

NEW JERSEY AGRICULTURAL EXPERIMENT STATION

Department of Agronomy

Title: Residual Fertilizer Studies on Permanent Pasture Sward.

Leaders: H. B. Sprague, Gilbert H. Ahlgron, and W. Ward Henderson.

Series I. Comparison of lime and minerals - lime preceding minerals.

Series II. Comparison of three strains of white clover in conjunction with lime and minerals.

Series III. Test of phosphates from various sources; with and without lime. (Includes calcined phos., Ca-metaphos., Di-sodium phos., and superphos.).

Series IV. Test of Calcium silicates (quenched and unquenched).

Series V. Glycerophosphates (included Na and calcium glycerophosphate).

Series VI. Ethyl phosphate series.

These pasture plots were established several years ago. Lime or minerals were added to some plots in 1939, and to others in 1940, none in 1941. Nitrogen was applied in April, with additional amounts in June on certain designated plots. All plots were mowed regularly at 14-day intervals.

Conclusions for 1941. (1) There was a substantial residual effect from lime and mineral fertilization as measured by total yield and percentage of clover. (2) The combination of nitrogen and mineral fertilization stimulated yields but caused a strong reduction in percentage of clover.

Title: Comparative Yield Test and Cutting Treatments for 14 Grasses and 3 Legumes.

Leaders: H. B. Sprague, Gilbert H. Ahlgren, and W. Ward Henderson.

The species in this test were planted in late August and did not produce good stands, due to extreme fall drought. Spring reseeding of both grasses and legumes appears to be necessary. Cutting rates favorable for Ladino clover and for wild white clover are to be practiced.

The grass species are as follows: meadow fescue, tall fescue, timothy, reed canary, brome, tall oat, orchard grass, Kentucky and Canada bluegrass, Italian, and perennial ryegrass, redtop, red fescue, and colonial bentgrass. The three legumes are: Birdsfoot trefoil, Kent wild white clover, and Ladino clover. The legumes were seeded across the grass plots, so that each legume will be observed in combination with each of the grasses.

Title: Comparative Test of Grasses and Legumes under Grazing Conditions.

Leaders: H. B. Sprague, Gilbert H. Ahlgren, and W. Ward Henderson.

The grass species in this test include the following: tall meadow fescue, orchard grass, Kentucky bluegrass, reed canary, timothy, brome grass, and meadow foxtail; and the legumes are: Ladino clover, birdsfoot trefoil, Kent wild white clover, strawberry clover, crimson clover, and subterranean clover, and Korean lespedeza. The planting was made in late August. At present it appears that the grasses will survive the winter, but that the legumes may need to be reseeded. The legumes were seeded across the grass plots, so that each legume will be grown with each of the grasses.

Title: Demonstrations on Establishment of Improved Species in Permanent Pastures.

Leaders: H. B. Sprague, Gilbert H. Ahlgren, and W. Ward Henderson.

Six cooperative pasture demonstrations on farm pastures were located in Cumberland, Hunterdon, Morris, Sussex, and Warren counties, in August and September 1940. For comparison, a standard grass and legume mixture recommended by the station, and a special seed mixture made up of supposedly superior strains of species from the U. S. Department of Agriculture, were planted at the same time and under equal conditions. Both mixtures were markedly superior to the unimproved pasture or the local seed mixture in terms of dry matter returns from periodic clippings. In establishing these trials, the old sod was disked, lime and a complete fertilizer was worked in, and manure was spread, if available. The old sod was partially killed by this treatment, thus providing an opportunity for new seedings.

Title: Grass and Legume Introduction Nursery.

Leaders: H. B. Sprague, Gilbert H. Ahlgren, and W. Ward Henderson.

About 250 species and strains of grasses and legumes are under observation as to their possibilities for pasture, hay, erosion control, mulch, and lawns.

Title: Uniform Grass and Legume Nursery.

Leaders: H. B. Sprague, Gilbert H. Ahlgren, and W. Ward Henderson.

Both row tests and small plot tests of 50 grass strains are under observation. Studies on growth habits and yielding ability are the main objectives. One or more strains of each of the following species are under test: Kentucky bluegrass, reed canary, timothy, Italian ryegrass, perennial ryegrass, meadow fextail, meadow fescue, brome grass, red fescue, redtop, velvet bent grass, and Canada bluegrass.

Department of Dairy Husbandry

Title: Belle Ellen Pasture Experiment.

Leader: C. B. Bender

Fifty-seven head of milking Guernsey cows pasturing 45 acres of variously fertilized pastures under rotation

management obtained 60% of their nutrients from pasture. They produced a daily average of 30.2 pounds of 4% fat corrected milk, with limited supplemented grain and hay feeding for a grazing period of 136.5 days.

Title: Fertility Levels on Dairy Farms.

Leaders: C. B. Bonder and Firman E. Boar.

An attempt will be made to determine the optimum levels of fertility for the production of pasture grasses and legumes. Ten pastures on Belle Ellen farm, ranging in size from 4 to 7 acres, have been divided into four areas (without fences) representing four fertility levels to be employed.

Five of the pastures are devoted to bluegrass-white clover mixtures and five to Ladino clover mixtures. In each of the groups of five, one pasture is used for a limestone, one for a phosphate, one for a potash, one for a nitrogen, and one for a manure experiment. The conditions are standardized, at an estimated optimum, with reference to all of the fertility elements except the one under test.

The standard treatment, on an annual basis, as topdressings on the five permanent pastures is:

50 pounds P_2O_5
 50 pounds K_2O
 50 pounds N (as needed).
 Limestone to pH 6.0 for top
 $3\frac{1}{2}$ inches of soil

Pasture 1. In testing for the P_2O_5 needs of the soil and crop, 50 pounds each of K_2O and N are supplied, with pH 6.0. The four phosphate levels are 0, 25, 50, and 100 pounds of P_2O_5 per acre.

Pasture 2. In testing for the K_2O needs of the soil and crop, 50 pounds each of P_2O_5 and N are supplied with pH 6.0. The four potash levels are 0, 25, 50, and 100 pounds of K_2O per acre.

Pasture 3. In testing for the N needs of the soil and crop, 50 pounds each of P_2O_5 and K_2O are supplied with pH 6.0. The four nitrogen levels are 0, 25, 50, and 100 pounds of N per acre (half in April; half in June).

Pasture 4. In testing for the limestone needs of the soil and crop, 50 pounds each of P_2O_5 , K_2O , and N are applied over the whole field. Four pH levels are maintained at natural pH, and at 5, 6, and 7.

Pasture 5. In testing for the manure needs of the soil and crop, 50 pounds of P_2O_5 are applied, with pH 6. The four manure levels will be 0, $2\frac{1}{2}$, 5, and 10 tons per acre.

The standard treatment on an annual basis, as top-dressings on the five Ladino clover pastures is:

50 pounds P_2O_5
100 pounds K_2O
No nitrogen
Limestone to pH 6.0 for top
7 inches of soil

Pasture 1. In testing for the P_2O_5 needs of the soil and crop, 100 pounds of K_2O are supplied, with a pH 6.0. The four phosphate levels are 0, 25, 50, and 100 pounds of P_2O_5 per acre.

Pasture 2. In testing for the K_2O needs of the soil and crop, 50 pounds of P_2O_5 are supplied, with a pH 6.0. The four potash levels are 0, 50, 100, and 200 of K_2O per acre.

Pasture 3. In testing for the N needs of the soil and crop, 50 pounds of P_2O_5 and 100 pounds of K_2O are supplied with pH 6.0. The four N levels are 0, $12\frac{1}{2}$, 25, and 50 pounds of N per acre.

Pasture 4. In testing for the limestone needs of the soil and crop, 50 pounds of P_2O_5 and 100 pounds of K_2O are supplied. The four pH levels are the natural pH, and at 5, 6, and 7.

Pasture 5. In testing for the manure needs of the soil and crop, 50 pounds of P_2O_5 and 50 pounds of K_2O are supplied with pH 6.0. The four manure levels are 0, $2\frac{1}{2}$, 5, and 10 tons per acre.

Yields will be estimated on an acre basis by total dry weight on each quarter of the pastures, samples obtained by random clipping, harvested just before the cattle are turned in to graze. If unequal grazing occurs on any part of a pasture, the mower will be used to equalize the growth.

Complete records will be kept of yields and costs, and analysis of soil and herbage will be made from time to time.

Title: Pasture Fertilization in Relation to Carrying Capacity (Wyker).

Leader: C. B. Bender.

The Wyker Farm produced in 1941 an average of 2180 pounds of total digestible nutrients per acre. A total of 69 Holstein and Guernsey dairy heifers grazed the 44 acres under rotational management for an average of 189.8 one thousand pound cows during a grazing period of 98 days.

Title: New Pasture Species.

Leader: C. B. Bender.

Observations as to palatability, recovery after grazing, and coverage of the ground of 15 plots of 1/40 acre each seeded in August 1940 and grazed by dairy heifers in 1941 are reported in table 1.

Table 1. Pure cultures of new pasture species.

		Herbage Analysis										Rank of		
		% of volunteer species										species		
Plot:	% of													
No.:	Species	Sown	Weeds	Kentucky	Blue	White	Clover	Crab	Foxtail	Coverage	Palatability	Recovery	Ground cover	
:	:	Species	:	:	:	:	:	:	:	:	:	:	:	
1	: Orchard S-26	: 69.6	: 12.6	: 5.5	: 6.3	:	:	:	:	: 94.0	: 2	: 3	: 5	
2	: Orchard Brago	: 73.1	: 11.1	: 3.4	:	:	: 3.4	:	:	: 91.0	: 2	: 3	: 3	
3	: Tall Oat Grass	: 68.1	: 12.6	:	:	:	:	:	: 10.3	: 91.0	: 4	: 1	: 6	
4	: Meadow Fescue	: 72.7	: 17.3	:	:	:	:	:	:	: 90.0	: 7	: 4	: 4	
5	: Tall Fescue	: 75.2	: 17.6	:	:	:	:	:	:	: 96.0	: 7	: 4	: 2	
6	: Reed Canary	: 81.9	: 10.1	: 2.6	:	:	:	:	: 3.4	: 98.0	: 3	: 2	: 1	
7	: Brome Svalof	:	Annual early kill											
8	: Timothy Cor-	:	:	:	:	:	:	:	:	:	:	:	:	
	: nell 4030	: 44.5	: 14.8	:	: 18.5	: 12.0	:	: 4.2	: 94.0	: 1	: 5	: 9	:	
9	: Timothy Cor-	:	:	:	:	:	:	:	:	:	:	:	:	
	: nell 4038	: 41.6	: 19.3	: 4.9	: 13.8	: 5.0	:	: 7.4	: 92.0	: 1	: 5	: 10	:	
10	: Timothy Welsh	:	:	:	:	:	:	:	:	:	:	:	:	
	: S-50	: 35.0	: 18.5	: 7.5	: 25.0	: 2.5	:	: 1.5	: 90.0	: 1	: 6	: 12	:	
11	: Meadow Foxtail	: 41.6	: 20.0	: 10.0	: 8.6	: 2.8	:	: 7.0	: 90.0	: 5	: 5	: 12	:	
12	: Danish O to fte	:	:	:	:	:	:	:	:	:	:	:	:	
	: Bluegrass	: 50.4	: 21.7	:	: 21.7	:	:	: 1.2	: 95.0	: 6	: 5	: 7	:	
13	: Canada Mr-Cro p-	:	:	:	:	:	:	:	:	:	:	:	:	
	: ing Brome	: 29.6	: 25.2	: 18.0	: 10.6	:	:	: 4.6	: 88.0	: 5	: 6	: 13	:	
14	: Crooping	:	:	:	:	:	:	:	:	:	:	:	:	
	: Brome	: 49.8	: 11.5	: 18.6	: 11.5	:	:	: 1.6	: 93.0	: 4	: 5	: 8	:	
15	: Birdsfoot	:	:	:	:	:	:	:	:	:	:	:	:	
	: Trefoil	: 40.2	: 19.4	: 20.6	: 6.4	:	:	: 5.4	: 92.0	: 8	: -	: 11	:	

Title: Ladino Clover

Leader: C. B. Bender

An open pasture sod seeded to one pound per acre of Ladino clover in April 1939 contained 60% Ladino in the fall of 1941.

Ladino seeded in a dense Kentucky bluegrass sod in April 1940, followed by a 5-ton manure application, showed count of 31% Ladino in the fall of 1941.

A plot of Orchard S-26 and Ladino at the end of the second year showed a population count of 45% Orchard and 55% of Ladino. The plot yielded well, recovered quickly after grazing, was highly palatable, and presented a good balance of grass and clover for pasturing purposes, with the exclusion of volunteer species.

New combinations of Ladino being tried on a field scale are Ladino and Milton timothy, Ladino and Brage Orchard, Ladino and smooth brome. These pastures will be grazed by lactating dairy animals in 1942.

Ladino-Reed canary combination yielded 8.7 tons green weight per acre in two cuttings with approximately three tons of third growth material remaining in stand for winter cover. This is a very promising combination for low-lying areas.

Title: Grass Silage

Leader: C. B. Bender

Effect of Oat Pea Phosphoric Acid Silage on the Calcium Phosphorus Metabolism of Dairy Heifers. Three

experiments were carried out to study the effect of oat-pea phosphoric acid silage on the calcium, phosphorus, and nitrogen metabolism of dairy heifers over a period of five months. Eight Holstein heifers were divided into four groups of two heifers each as follows:

- Group I. Phosphoric acid silage alone.
- Group II. Phosphoric acid silage plus ground limestone.
- Group III. Phosphoric acid silage, mixed timothy, and clover hay.
- Group IV. Phosphoric acid silage, mixed timothy, and clover hay and 4 pounds of grain each.

Weekly analyses were made for calcium of the blood serum, inorganic phosphorus of the blood plasma, and pH of the urine. The inorganic phosphorus of the blood increased sharply in all groups soon after the animals were placed on the experimental rations while the calcium of the blood serum remained nearly constant throughout the experiment. The pH of the urine decreased in all groups during the first five weeks of the experiment. Animals which received phosphoric acid silage alone produced urine of lower pH than those which received limestone supplement. This indicated that the limestone, when added as a supplement to the phosphoric acid silage, contributed favorably to the acid-base economy of the heifers.

Calcium, phosphorus, and nitrogen balance studies were made on the heifers after they had received phosphoric acid silage for a period of 123 days. All heifers were in positive calcium and phosphorus balance during the 12-day balance trial. The animals during the mineral balance trial were maintained at approximately the same nitrogen intake. The daily positive retention of nitrogen was the highest in Group IV, receiving phosphoric acid silage, hay, and grain. Heifers in Group II, receiving phosphoric acid silage plus limestone supplement were in a positive nitrogen balance while heifers in Group I were in a definite negative nitrogen balance. The only variable factor between these two groups was the limestone supplement. This indicates that a mineral acid diet favors a greater excretion of nitrogen than a basic diet.

A Study of the Feeding Value, Effect of Growth, pH of the Urine and Digestibility of Phosphoric Acid Grass Silage When Fed to Dairy Heifers. Phosphoric acid oat and pea silage and phosphoric acid oat silage, when fed with limestone, were found to be equal in feeding value to the same crops preserved with molasses and to corn silage, using growth as the criterion. Mixed hay and silage in the proportions fed did not support normal gains in one experiment.

Phosphoric acid oat and pea silage and phosphoric oat silage when fed alone decreased the pH of the urine of the animals to below 6.0. The addition of limestone corrected this in the case of oat and pea silage but had no effect on the pH of the urine in the case of oat silage. However, when limestone was added to the ration of phosphoric oat silage it had a sparing effect on the base reserves as indicated by weight gains when compared to the weight gains

of the group receiving the phosphoric acid silage alone. Mixed hay did not correct the pH of the urine but increased it slightly when fed with phosphoric acid silage. Normal values for the pH of the urine were established two weeks after the feeding of phosphoric acid silage was terminated.

Digestibility coefficients were determined for phosphoric acid oat and pea silage in a 15-day digestion trial. No significant effect on digestibility was found when limestone was added to the silage.

Phosphoric acid grass silage was found to be a satisfactory roughage when fed with limestone and mixed hay. When fed alone, phosphoric acid grass silage lowered the pH of the urine to below 6.0 in the dairy heifer. This was corrected in the case of oat and pea silage by the addition of limestone but was not corrected in the case of oat silage. A mixture of one-half limestone and one-half equivalent in neutralizing power of sodium bicarbonate corrected the pH to above 7.0 in the case of phosphoric acid oat silage. No appreciable difference was found in the digestibility of phosphoric acid grass silage when fed alone or when supplemented with limestone.

The Milk Production Values of Molasses Grass Silage, Phosphoric Acid Grass Silage, and Corn Silage. Two continuous feeding trials with three groups of cows were conducted to determine the production values of molasses grass silage, phosphoric acid grass silage, and corn silage. Each experiment covered 18 weeks and 15 animals were fed in each case. There was practically no difference in the performance of the two grass silage groups, but there was a slight advantage for the corn silage group in performance as measured by 4% milk production, per pound of total digestible nutrients consumed and by body weight changes.

Although there appears to be a tendency for corn silage to have a higher production value than the other two silages, the results obtained in the two experiments justifies the conclusion that the difference between the three silages is so slight, when compared as to milk production, total digestible nutrient consumption, and body weight changes, that it is within the limits of experimental error. From the results of these experiments it can be concluded that molasses grass silage or phosphoric acid grass silage is equal in feeding value to corn silage.

Manural Values of Phosphoric Acid Silage and Molasses Silage. Manure was collected twice weekly for a 6-weeks period and stored in cement pits under cover. Aside from the silages fed and the addition of limestone to the acid silage, conditions were the same.

Table 2. Analysis of molasses and phosphoric manures on an air-dry basis.

:Date sample:		:	:	:	:
Manure :	taken :	% Nitrogen:	% Ash :	% Calcium:	% Phosphorus
<u>Molasses:</u>					
1 :	1-27 :	1.59 :	9.87:	1.43 :	0.49
2 :	2-28 :	1.40 :	12.38:	1.26 :	0.39
3 :	3-2 :	1.24 :	11.67:	1.17 :	0.39
4 :	5-1 :	1.40 :	11.59:	1.14 :	0.43
5 :	:	:	11.06:	1.36 :	0.48
Average :	:	1.41 :	11.31:	1.27 :	0.44
<u>H₃PO₄</u>					
1 :	1-27 :	1.36 :	11.45:	1.67 :	1.08
2 :	2-28 :	1.26 :	13.47:	1.43 :	0.88
3 :	3-2 :	1.28 :	13.82:	1.69 :	1.00
4 :	5-1 :	1.29 :	16.94:	1.22 :	0.96
5 :	:	:	13.95:	1.70 :	1.12
Average :	:	1.30 :	13.93:	1.54 :	1.01
:	:	:	:	:	:

There is little or no difference in per cent nitrogen. The group receiving the phosphoric acid silage seems to have higher values consistently for ash, but that could probably be best explained by the fact that the sand from the aisles probably was not evenly distributed through the manure. In per cent calcium, the phosphoric acid silage group also has higher values. The added limestone accounts for that difference, however. In per cent phosphorus the phosphoric acid silage gave twice as great a value in every case as did the molasses silage.

A Study of the Fermentation Products of Alfalfa Silage Preserved with Phosphoric Acid. An experiment was set up to make a study of the chemical changes taking place in alfalfa phosphoric acid silage. The study was to begin at the time of ensiling the alfalfa and to extend over a period of 34 days.

A concrete silo at Beemerville was used. The alfalfa was preserved with 24 pounds of blended phosphoric acid per ton. The acid was diluted with equal parts of water and applied by gravity at the cutter. A total of 94.9 tons of green alfalfa was put up for silage. Most of the alfalfa was in three-fourths bloom with a herbage count of an average 83.5% alfalfa, 8.3% grass, mostly timothy, 3.6% red clover, and 5.6% weeds.

At a 10-foot level a float was placed on the silage and a representative sample taken. After that at different intervals samples were taken for a period of 34 days. After the first day, the samples were taken in the approximate region of the float. The sampling was done by means of a soil auger, three feet in length. A hole was bored in the door and a sample was pulled out with the auger. This method of sampling was by no means satisfactory. After a sample was taken, the hole was immediately plugged but even then there was some spoilage. To avert this region, samples were taken at different angles in the area of the float.

The results indicate a protein breakdown and also a formation of acetic and lactic acid. There was some increase in ammonia nitrogen, water soluble nitrogen, and amino acids, although the data showed considerable variation. After the first day the sugar was used up in the process of fermentation. The pH of the silage varied from day to day and, in general, appeared to be lower after the third day of fermentation.

NEW YORK (CORNELL) AGRICULTURAL EXPERIMENT STATION

Department of Agronomy

Title: The Value of Birdsfoot Trefoil as a Hay and Pasture Legume in New York.

Leader: H. A. MacDonald

Investigations relative to the agricultural possibilities of birdsfoot trefoil (Lotus corniculatus) for this region as reported in 1940 were continued. Two-year production results have been obtained on the earlier 1939 seedings at both the Caldwell Field and Mount Pleasant Stations. The first-year results of the 1940 seedings were obtained and, in addition, new trials added including:

1. Strain tests for hay and pasture.
2. Pasture management studies.
3. Seed production studies.
4. Methods of establishment in old sod.
5. Ecological adaptation studies.
6. Strain increase areas.

In addition to these local investigations, some 120 farm trials on as many farms in 16 counties in the southern portion of New York State were initiated. These trials consist of plots one acre in size and include comparisons of (a) birdsfoot trefoil and timothy seeded with no comparison crop, (b) similar to (a) but with a comparison crop, (c) the farmers' regular seeding mixture, and (d) the farmers' regular seeding mixture plus the addition of 1.5 pounds Ladino clover. Eighteen soil types and many other farm variables are covered by this trial. Records relative to previous area history and treatment, together with notes on establishment and fall stand have been obtained. Further records, including yield as hay, botanical composition, and duration of stand, will be obtained over a period of years.

The station tests in 1941 again showed the inability of birdsfoot trefoil to withstand severe competition, particularly in the early stages of growth. Seedings made in early spring were superior to those of summer or autumn. The rates of seeding between 4 and 16 pounds per acre were found to be of less importance than the date of seeding and efficiency of seedbed preparation.

When seeded with various grasses for pasture, birdsfoot trefoil continued to do best with the less dense sward formers as Kentucky bluegrass, Canada bluegrass, orchard grass, and red fescue (Olds). The dry matter production was much lower when seeding was with perennial ryegrass, redtop, or Rhode Island bent. At Caldwell Field, birdsfoot trefoil compared favorably with wild white clover as a pasture legume, while at Mount Pleasant the yield was greater than wild white clover when clipped about one inch in height. Ladino clover was higher in yield in 1940 but considerably less in 1941 at the latter station. Certain selected strains of birdsfoot trefoil were superior to others in yield both in 1940 and 1941. Such strains are being increased for further testing and propagation.

Chemical studies carried out on both the 1940 and 1941 crop have shown birdsfoot trefoil to be equivalent to alfalfa or wild white clover when used as hay or pasture in chemical composition.

Title: A Study of Plant Associations for Pasture Purposes.

Leader: D. B. Johnstone-Wallace.

Grasses and legumes are grown alone and in association in field plots and clipped with a power lawn mower fitted with a rubber-covered roller drive and an efficient collecting box. The machine is set to cut to $3/4$ inch from the surface when placed on level concrete. A small sickle bar mowing machine is used to harvest plots for silage.

The pasture plots are cut at intervals throughout the growing season to simulate periodical close grazing. The yield of green material from each clipping is obtained and samples are dried to determine the yield of oven-dried material. The total dry matter, nitrogen, phosphorus, and calcium content are determined by chemical analyses. Botanical analyses are also made.

Results were obtained in 1941 from plots seeded in 1933, 1938, 1939, and 1940. These tend to confirm the conclusions previously reached that the legumes of greatest value under the conditions prevailing in these experiments are several varieties of wild white clover, Ladino white clover, New York wild broad and narrow-leaved birdsfoot trefoils, and, in some seasons, yellow trefoil. The birdsfoot trefoils show to best advantage in dry seasons such as 1941.

The outstanding grasses, when grown in association with wild white clover under simulated pasture conditions, continued to be varieties of Kentucky bluegrass, creeping red fescue, pasture timothy, and winter-hardy varieties of perennial ryegrass.

In mixtures intended for a combination of silage and pasture, Ladino white clover continues to give excellent results and the most valuable grasses for growing in association with this legume appear to be orchard grass, especially the late-flowering leafy varieties such as Aberystwyth S 143, smooth brome grass, and tall oat grass. Timothy varieties have not persisted well and Kentucky bluegrass, although it is able to persist, contributes only a small percentage of the total herbage.

A new series of plots was seeded in the spring of 1941 to determine, if possible, whether returning to the soil after each clipping, in the form of manure or clippings,

fertilizer constituents, equivalent to those which would be returned under actual grazing conditions, would lead to greater differences in the yields obtained from species and varieties of grasses under experiment. It is hoped that data will be obtained from these plots in 1942.

The grasses and legumes being tested under simulated grazing conditions are also being tested under actual grazing conditions on the beef cattle pastures at Cornell University. Special attention is being paid to the palatability of species and varieties of grasses and legumes and their persistence when closely grazed periodically.

Title: Pasture Survey of New York.

Leader: D. B. Johnstone-Wallace.

Periodical examinations are made of pastures in which recommended methods of fertilizer treatment, grazing management, and seeding have been followed so that their effectiveness under practical farming conditions can be determined.

Title: The Improvement of Pastures by Fertilizer Treatment.

Leader: D. B. Johnstone-Wallace.

Investigations are being continued in Caldwell Field and in the Herford Pasture at Cornell University to determine the influence of various methods of fertilizer treatment and seeding upon the seasonal productivity, chemical composition, and botanical composition of an old pasture sward.

Title: The Management of Uncultivated Plant Covers to Conserve Soil and Water.

Leaders: D. B. Johnstone-Wallace, in cooperation with John Lamb, Jr., of the Soil Conservation Service.

A series of plots on a 10% slope was seeded with a Cornell Pasture Mixture. One plot was fertilized and lightly grazed, another fertilized and heavily grazed, and the third unfertilized and heavily grazed.

Another series of plots on a 23% slope, fertilized and unfertilized, were seeded with and without wild white clover to various grasses. The plots were subsequently grazed by sheep.

The results of these experiments have been submitted for publication.

A new series was established in the spring of 1940 to determine the value of New York wild narrow and broad leaved birdsfoot trefoils, Ladino white clover, Kent wild white clover, and New York Cornell No. 1 wild white clover.

Title: The Influence of Grazing Management upon the Yield, Botanical Composition, and Chemical Composition of Pasture Herbage.

Leaders: D. B. Johnstone-Wallace, L. A. Maynard, and Keith Kennedy.

This project was started in May 1940 to determine the part played by grazing management in pasture improvement. A uniform stand of Kentucky bluegrass and wild white clover seeded in May 1938 was divided into plots which were clipped during the growing seasons of 1940 and 1941 at various dates and heights down to various heights from the ground surface with the aid of a power lawn mower fitted with a rubber-covered roller drive, and a sickle-bar mowing machine to simulate various methods of grazing management.

Records were obtained of the seasonal production, botanical composition, and chemical composition of the herbage. During 1941, additional plots were established including further replications.

The plots present a striking appearance and it is evident that changes in management methods profoundly influence the botanical composition. The yields obtained from plots cut to within 1/2 inch of the ground surface greatly outyield those cut to within 2 inches or 4 inches of the surface. The sward produced is more dense and there is a smaller accumulation of dead material.

The indications are that plots cut to within 1/2 inch of the ground surface when the herbage reaches a height of 4 inches are developing the most satisfactory type of pasture sward. No significant increase in yield of dry matter has been obtained from plots cut less frequently. The legume content is decreased and the feeding value of the herbage is reduced when the plots are harvested at a more mature stage of growth.

In the spring of 1940, two 3-acre plots were seeded with the Cornell Pasture Mixture containing Kentucky bluegrass, Canada bluegrass, rough stalked meadow grass, Victoria perennial ryegrass, timothy, New York wild broad leaved birdsfoot trefoil, and wild white clover. Adequate applications of superphosphate and lime were made. One of these plots has been grazed by beef cattle to within 1/2 inch of the ground surface whenever the herbage reached a height of about 4 inches. The other was lightly grazed with half the number of stock when the herbage reached a greater height. The records obtained indicate that the cows consumed less herbage per day when it was allowed to reach the greater height and that there was considerable reduction in the feeding value of the herbage.

Title: The Influence of the Grazing Habits of Cattle on the Composition, consumption, and utilization of Pasture Herbage.

Leaders: D. B. Johnstone-Wallace and Keith Kennedy.

During the grazing seasons of 1940 and 1941, records were obtained during continuous periods of 24 hours of the grazing habits of beef cattle when receiving no supplementary feed. The amounts of herbage consumed in a day in pastures of various types and at various stages of growth were determined. Results of considerable practical value were obtained and some of these were included in a thesis presented to the faculty of Cornell University in June 1941. Further data were obtained in 1941 and a report on the investigation is being prepared for publication.

Title: A Determination of the Feeding Value of Pasture Herbage in Experiments with Sheep and Guinea Pigs with Special Reference to the Protein and Lignin Content of the Herbage Cut at Various Stages of Maturity Throughout the Grazing Season.

Leaders: D. B. Johnstone-Wallace, L. A. Maynard, and R. T. Allman.

This investigation was completed in 1941 and the results included in a thesis presented to the faculty of Cornell University. The conclusions drawn were that no detrimental effects resulted from feeding high protein pasture herbage to guinea pigs; that the digestibility of pasture

herbage depended on the lignin content, the relationship being inverse between the lignin content and the digestibility of the organic matter; that the nutritional value of pasture herbage, not deficient in minerals or vitamins, is mainly dependent on the digestibility of the organic matter; that the lignin content of pasture herbage and the digestibility depend more on the stage of maturity and rate of growth than on the botanical composition; that the ether extract of pasture herbage is of doubtful feeding value; that guinea pigs are satisfactory laboratory animals for determining the nutritional value of pasture herbage; and that good pasture management should aim at having the maximum amount of immature, rapidly growing pasture herbage available continuously throughout the grazing season.

Title: Pasture Seeding Mixture Experiment (Mt. Pleasant Farm).

Leader: R. B. Musgrave.

Object: To determine the relative merits of seven different pasture seeding mixtures on hill land typical of southern New York.

Soil: Mardin-Volusia silt loam. Experiment on a west slope of about 12%.

Previous History of Field:

An old pasture abandoned for several years. Very unproductive.

Soil Treatments:

Entire 15-acre field received limestone at the rate of 1.3 tons and calcium metaphosphate (64% P_2O_5) at the rate of 200 pounds per acre drilled on plowed land just prior to seed bed preparation.

Half of the area received in addition 112 pounds each of $NaNO_3$ and KCl ; the other half (lower), 12 tons of fresh cow manure.

Type of Plot Layout:

Randomized block with eight replications for each seeding mixture, four of which received manure and four the mixture of $NaNO_3$ and KCl .

Pasture Management:

The entire 15-acre pasture was pastured with dairy heifers. To get yields, a strip about 150 feet

wide at the junction of the manured and chemically fertilized blocks and across all plots was fenced off with an electric fence. When the grass within the enclosure reached 4-6 inches, two 40-inch strips about 60 feet long were harvested on each plot. Samples were taken for dry weight determination and chemical analyses. After these strips were harvested, 30-40 cattle were turned into the enclosed area to graze the rest of the herbage. Usually only 1-2 days were required. The cattle were then removed until the herbage had again reached grazing height and the above procedure was then repeated.

Table 1. Yields for 1940 and 1941.

		: Yields in lbs. dry matter :Ave. N content			
Seed Mixtures		per season		:1st & 2nd cut-	
		1940	1941	: tings, 1940, %	
No.	Composition	Barn-:	Barn-:	: Barn-:	
		Lb. yard	:Comm'l:	yard	:Comm'l:
		manure:	Fert.	manure:	Fert.
1	Ky. bluegrass	8:	:	:	:
	Canada blue-	:	:	:	:
	grass	2:	:	:	:
	Rough stalked	:	:	:	:
	meadow	1:	:	:	:
	Timothy	6:	:	:	:
	Perennial rye-	:	:	:	:
	grass	5:	:	:	:
	Kent w.w. clover	1:	:	:	:
	Yellow trefoil	2:	:	:	:
	(Cornell Spec,	:	:	:	:
	Past. Mixture)	25; 2096	: 1441	: 1555	: 1413 :2.359 :2.242
2	Ky. bluegrass	5 :	:	:	:
	Red top	5 :	:	:	:
	Timothy	5 :	:	:	:
	Ladino white	:	:	:	:
	clover	2 :	:	:	:
	Alsike clover	3 :	:	:	:
		20 :	3415	: 2746	: 2714 : 2072 :2.867 :2.543
3	Ky. bluegrass	5 :	:	:	:
	Red top	5 :	:	:	:
	Timothy	5 :	:	:	:
	Kent w.w. clover	15 :	:	:	:
	Alsike clover	3 :	:	:	:
		19.5:	2455	: 2391	: 1563 : 1666 :2.826 :2.701

Table 1. (Continued).

Seed mixtures		Yields in lbs. dry matter per season				Ave. N content	
		1940		1941		1st & 2nd cuttings, 1940, %	
No.	Composition	Barn-		Barn-		Barn-	
		Lbs. yard	Comm'l	Lbs. yard	Comm'l	Lbs. yard	Comm'l
		manure	Fert.	manure	Fert.	manure	Fert.
4.	Ky. bluegrass	10:	:	:	:	:	:
	Kent w.w.	:	:	:	:	:	:
	clover	1:	:	:	:	:	:
	Perennial rye-	:	:	:	:	:	:
	grass	5:	:	:	:	:	:
		16:	1995	1406	1420	1054	2.546
							2.105
5	Ky. bluegrass	10:	:	:	:	:	:
	Kent w.w.	:	:	:	:	:	:
	clover	1:	:	:	:	:	:
	Med. red	:	:	:	:	:	:
	clover	4:	:	:	:	:	:
	Alsike clover	3:	:	:	:	:	:
		18:	3277	2725	2176	1727	3.116
							2.999
6	Brome grass	10:	:	:	:	:	:
	Ladino clover	1:	:	:	:	:	:
	Birdsfoot	:	:	:	:	:	:
	trefoil	2:	:	:	:	:	:
		13:	3049	2235	1791	1488	2.846
							2.722
7	Timothy	8:	:	:	:	:	:
	Ky. bluegrass	3:	:	:	:	:	:
	Alfalfa	4:	:	:	:	:	:
	Med. red	:	:	:	:	:	:
	clover	2:	:	:	:	:	:
	Alsike clover	1:	:	:	:	:	:
	Yellow tre-	:	:	:	:	:	:
	foil	1:	:	:	:	:	:
	Ladino white	:	:	:	:	:	:
	clover	1:	:	:	:	:	:
	(Cornell Hay-	:	:	:	:	:	:
	Past. Mix-	:	:	:	:	:	:
	ture)	20:	3612	3269	2275	2398	3.047
							2.808

DEPARTMENT OF ANIMAL HUSBANDRY

Title: A Comparison of Various Forage Crops as Temporary Pastures for Lambs.

Leader: J. P. Willman.

Further work was conducted during the summer of 1940 to compare the carrying capacity and methods of growing broad-leaved rape and dwarf Essex rape. The yield of these crops was measured by recording the hours of sheep and lamb grazing that were furnished by each crop. An average of this trial and similar trials conducted in 1937 and 1938 shows very little difference in the carrying capacity of these crops when sown broadcast or in rows about 28 inches apart. The results of these tests do not justify the extra labor required in planting, hoeing, and cultivating the crop grown in rows.

An average of the results obtained in seven separate trials at this station shows that dwarf Essex rape produced about 10% less units of grazing per acre than did broad-leaved rape. The broad-leaved rape produced more hours of grazing during six of these seven trials.

Title: The Losses and Changes Accompanying Ensiling of Legumes and Non-Legumes with Various Amounts of Phosphoric Acid and the Feeding Value of Phosphoric Acid and Molasses Silage.

Leaders: E. S. Savago, E. S. Harrison, and N. P. Ralston.

Since the last Annual Report two trials have been finished under this project.

a. The Palatability of Phosphoric Acid and Molasses Silage Compared with Corn Silage. In the winter of 1939-40 a continuous feeding trial of 14 cows was set up to study the palatability of molasses and phosphoric acid grass silage compared with corn silage when fed with limited amounts of dry hay to dairy cows. The corn silage was cut in the dent stage of maturity and the mixed legume grass silage was cut at the one-half bloom stage of legumes. Molasses was applied at the rate of 60 pounds per ton of green material and phosphoric acid (68% food grade) was applied at the rate of 24 pounds per ton of silage. Four groups of cows were fed, balanced as closely as possible

in all essential respects. Six cows received corn silage, eight cows molasses grass silage, five cows phosphoric acid grass silage, and five cows phosphoric acid grass silage plus nine ounces of calcium carbonate (Ca CO_3) per 100 pounds of silage. This amount of calcium carbonate was considered ample to neutralize the quantity of phosphoric acid added to grass silage for preservation. Dry mixed legume hay was limited to slightly less than one-half pound per day per 100 pounds of body weight so that a critical test would be made on the palatability of the silage. Silage was fed at will. The cows consumed approximately 4-1/2 pounds of silage per 100 pounds of live weight in all groups. A grain mixture containing 13.3% digestible protein and 74% total digestible nutrients was fed at the rate of 1 pound of grain to 2.8 pounds of milk.

The observations of appetite, daily weigh-backs, the condition of the cows, changes in body weight during the 14-week continuous feeding trial, and milk and fat production records showed that there was no difference in palatability among the four kinds of silage fed. While the purpose of the experiment was to test principally the palatability of the four kinds of silage fed, it may be noted that there was no significant difference among the four groups as to the production of fat-corrected milk. All the cows gained slightly in body weight.

b. The Nutritive Value of Molasses Legume Grass Silage Compared with Corn Silage for Milk Production. The experiment reported above carried on in the year 1939-40 showed that legume grass silages preserved with either phosphoric acid or molasses were as palatable as corn silage. With this in mind, in 1940-41 a double reversal feeding trial was set up to study the nutritive value of molasses legume grass silage compared with corn silage when fed with a limited amount of dry hay to dairy cows for milk production. The experiment was 27 weeks in length. Each period was eight weeks with one week for transition. Two groups of seven cows each were balanced as closely as possible in all respects.

The corn used for silage was somewhat immature due to an unfavorable season. The dry matter content of the corn silage was 21.56%. The material for the molasses legume and grass silage was cut approximately at one-half bloom stage of the legumes. The molasses was added at the rate of 55 pounds per ton of green material. Mixed

alfalfa and red clover made up about 60% of the mixture. The 40% of grasses was predominantly timothy. The dry matter content of the molasses legume grass silage was 27.03%.

The concentrate mixture was fed at the rate of 1 pound to 3.5 pounds of fat-corrected milk. Dry mixed legume hay was limited to approximately 1/2 pound per day per 100 pounds of body weight. Both kinds of silage were fed at the rate of 4.5 pounds per day per 100 pounds of live weight. The concentrate mixture was 13.3% digestible protein and 74% total digestible nutrients.

Results. The appetite of all cows was excellent, indicating no difference in palatability. The intake of food was approximately the same in both groups.

The cows on molasses legume grass silage produced 27.6 pounds of fat-corrected milk per day and gained slightly in body weight. The cows on corn silage produced 29.1 pounds of fat-corrected milk per day and gained approximately the same amount per day in body weight. These results indicate a slight difference in production in favor of corn silage.

This experiment will be repeated before final conclusions are drawn.

Department of Entomology

Title: White Grub and Other Forage Crop Insect Investigations.

Leaders: H. H. Schwardt and C. G. Lincoln

New infestations of brood C grubs were found along the entire south shore of Lake Ontario, and in the vicinities of Syracuse, Rome, Utica, and Schenectady in 1941. The Champlain Valley infestation has not extended its boundaries appreciably, but damage within the area was more severe in 1941 than in 1938. The infestation in the southern tier counties has spread northward from 5 to 10 miles at several points.

Preliminary experiments with milky disease (Bacillus popilliae Dutky) indicate that field control of native white grubs with this organism is not practical. Five replicates of eight treatments representing different rates and methods of applying the spore dust failed to give significant results. Further tests using first instead of second

year infestations are planned. This investigation has shown, however, that Bacillus popilliae is naturally present in the Champlain Valley. A survey of its general distribution in New York will be made.

Paradichlorobenzene and an emulsion of a mixture of methyl bromide and dichloroethyl-ether have been found effective as soil fumigants for use against white grubs under certain conditions.

Final counts on a series of pasture plantings including various commonly used pasture mixtures failed to show significant differences in susceptibility to infestation by grubs.

Field plot studies on the clover root borer have given further evidence that this pest is an important factor limiting the life of red clover stands, that clover plants are seldom attacked before the root crown has attained a diameter of five millimeters, that alsike and Ladino clovers are practically immune to attack and that Russian mammoth red and perennial red clovers are somewhat resistant to attack.

Department of Plant Breeding

Title: Timothy Breeding.

Leader: C. H. Myers

During the past year there has been an increased demand for our hay type No. 4059 which is being increased by Dr. H. B. Sprague of the New Jersey Experiment Station. From these reports variety No. 4059 seems particularly adapted to the regions of New Jersey, Maryland, and Delaware.

Department of Plant Pathology

Title: The Disease Factor in the Problem of Clover Stands in the State of New York, with Special Reference to Root and Crown Diseases.

Leaders: H. H. Whetzel, M. F. Barrus, and T. Sproston, Jr.

Apothecia of Sclerotinia trifoliorum, the cause of crown rot of legumes, were found again at Ithaca during the fall and due to the favorable weather conditions produced spores from the first week of October to the middle

of December. S. trifoliorum was also found destroying certain white clovers in experimental pasture plots at Caldwell field. If found in fields in the state, the disease might answer the question as to why white clover disappears from pastures.

Seedlings of red clover isolated as immune were found to be susceptible when grown to maturity. However, several mature plants grown under field conditions were highly resistant when tested with the crown rot organism. Crosses have been made using this material.

Perithocia of Pleospora herbarum, the leaf spot organism were found to be produced abundantly on the seed of red clover.

Fusarium root rot of red clover was very destructive in experimental plots at Ithaca as evidenced by a 50% reduction in stand.

Department of Poultry Husbandry

Title: Poultry Pastures.

Loaders: G. F. Houser, L. C. Norris, and J. H. Bruckner, in cooperation with D. B. Johnstone-Wallace and J. K. Wilson.

On June 5, 1941, four groups of pullots were placed on experiment. Each group contained approximately equal numbers of birds 7 to 10 weeks old at the start. Two groups were given a good grass range of white clover and Kentucky bluegrass; one of these was allowed grain and mash ad libitum, while the feed of the other was restricted by keeping the hoppers closed until noon. The third group had a good Ladino clover run with grain and mash available ad libitum. The fourth group was placed on a bare range but had feed available at all times.

At the end of three months there were no significant differences in average weights and gains. The per cent gains were 169%, 164%, 168%, and 168%, respectively, for the various lots. The food consumption was greatest in the bare range lot and smallest in the group which had its feed restricted. Since there were little differences in gains, the pounds of feed per pound of gain was greatest in the bare range lot (7.14), lowest in the pasture group which had the grain and mash restricted (6.31), and intermediate in the pasture groups receiving feed ad libitum (6.65 and 6.74).

By keeping the feed hoppers closed until noon and thus encouraging the consumption of grass as compared with feed available all day, the saving in feed for the 3-month period was .73 pounds per bird or 6.46% of the total feed. Birds on pasture with full feed as compared with birds on bare range with full feed, ate .82 pounds per bird less feed or 6.77% of the total. In comparing birds on bare range with full feed contrasted with pasture birds on restricted feed, the saving was 1.55 pounds per bird or 12.79% of the food intake during the 3-month period.

PENNSYLVANIA AGRICULTURAL EXPERIMENT STATION

Title: The Effect of Different Systems of Grazing, Cutting, and Fertilizing of White Clover.

Leader: H. B. Musser.

Referring to the report on this project (1940 Annual Report, page 91) submitted last year, the experimental work on testing persistence of white clover ecotypes was continued through the 1940 and 1941 seasons. Yearly analyses of the pasture turf were made by Amoldt's modified point quadrat method. All white clover ecotypes were grown in combination with Kentucky bluegrass and maintained under fertilizer, liming, and grazing practices as previously outlined. The results of this experiment are now computed and ready for publication. They indicate a favorable response by all ecotypes tested to potash applications, particularly when supplemented with lime. The results also show definite differences in persistence in relation to the environmental conditions which prevailed during the experimental period. Persistence under close grazing (2 inches) conditions was in the following order:

1. Louisiana and New Zealand.
2. Wild White.
3. Corn Belt.
4. Ladino
5. White Dutch.

Persistence under 4-inch grazing in the spring and fall showed a higher rank for Ladino than in the foregoing ratings.

Title: Source of Nitrogen in the Soil.

Leaders: J. W. White, F. J. Holben, and A. C. Richer.

An experimental set-up involving the use of 48 steel rims 4 feet in diameter and 2 feet deep has been designed to determine the role played by nitrogen fixing micro-organisms including Rhizobia, Clostridia, and Azotobacter. Four year grain rotations with timothy in one series and red and alsike clover in another are being compared. Kentucky bluegrass alone and white Dutch clover and bluegrass are also being compared in the experimental rims.

At the end of two years the rims seeded to Kentucky bluegrass alone produced a total of 3,594 pounds of dry matter per acre as compared with 6,835 pounds produced by a mixture of bluegrass and white clover. A total of 82 pounds of nitrogen per acre were removed in the hay from the bluegrass rims compared with 219 pounds of nitrogen per acre removed in the hay from the rims producing a mixture of white clover and bluegrass. These results are in agreement with data secured by Johnstone-Wallace of the New York (Cornell) Agricultural Experiment Station.

Title: Testing and Breeding Grasses for Pasture and Other Uses.

Leaders: H. B. Mussor, C. C. Wernham, and J. K. Thornton.

Referring to the progress report of this project (1940 Annual Report, page 90) a number of additional strains of creeping bent, Kentucky bluegrass, and red fescue have been selected. Yield and quality measurements, as previously reported, were made on all selections.

Additional records were secured on methods of disease control with creeping bent and fescue. A series of greenhouse pot experiments is under way to determine possible relationships between degree of disease infection and available nutrient ratios in the soil.

A preliminary trial planting of a five-strain blend of Kentucky bluegrass selections and a blend of red fescue types was made with Lotus corniculatus for determining the possible value of this legume alone and in combination with grass under practical grazing conditions.

Title: A Study of the Practicability of Commercial Production of Fescue and Other Grasses and Forage Crop Seed In Pennsylvania.

Leaders: H. B. Musser, C. C. Wernham, J. E. Nicholas, and J. L. E. McCord.

This project covers the production of new strains under the forage crop breeding program of the Department of Agronomy, development of practical methods of disease control in cooperation with the Department of Botany, seed conditioning problems, including cleaning and drying, in cooperation with Department of Agricultural Engineering, and securing of records on commercial seed production together with the possibilities for development of cooperative marketing organizations by the Department of Agricultural Economics.

During the past season, a series of experimental plots was planted for comparing seed production possibilities of a number of grass and legume species.

Commercial production of a 5-strain blend of red fescue was started. Approximately 2,000 pounds of this seed were harvested by three selected growers from plantings of 1 to 4 acres. Additional plantings of approximately 60 acres were made during the past season.

A commercial seed dryer was developed for conditioning "combined" seed. A preliminary report on the design, construction, and operation of this equipment has been published. (Agr. Eng., Vol. 22, No. 12, Dec. 1941).

Title: Testing and Breeding Strains of Clover.

Leaders: H. B. Musser and J. K. Thornton.

This project, as previously reported (1940 Annual Report, page 90), has been confined during past seasons to further tests of local strains for forage yields. In the last three years, three local strains of medium red, and two local strains of intermediate mammoth have been selected for blending to produce composites of each type for use in the seed production program in Pennsylvania.

Title: Legume Silage in Dairy Feeding.

Leaders: S. I. Bechdel, R. W. Stone, P. S. Williams, and
F. R. Murdock.

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Summary. Alfalfa-molasses or alfalfa-phosphoric acid silage enables the feeding of appreciably smaller amounts of concentrates for milk production when fed along with limited amounts of hay and corn silage. This plan of feeding also makes possible the use of less protein in the concentrates.

Alfalfa silage is not satisfactory as the sole roughage for milking cows. It should be fed in connection with at least 5 pounds of hay daily, which need not be of high grade. If corn silage is available, it is desirable to include it in the ration. The results of three different feeding trials indicate that a roughage combination of alfalfa or soybean silage, corn silage, and a small amount of hay is satisfactory for high-producing cows.

Alfalfa-molasses silage and alfalfa-phosphoric acid silage are of equal feeding value for milking cows provided that the original alfalfas are from the same source and the resulting silages are satisfactorily preserved.

Milking cows will tend to go "off-feed" on phosphoric acid legume silages when they are fed heavily. "Off-feed" cases rarely occur when molasses-legume silage is fed with hay in any amount, with corn silage, or with a combination of hay and corn silage. In one experiment, 7 out of 24 cows on alfalfa-phosphoric acid silage went "off-feed" after several weeks of feeding. Hay and corn silage were also included in the ration. Cows fed alfalfa-molasses silage in the same experiment gave no trouble in going "off-feed." Daily fluctuations in the amount of urine excreted prompted the belief that the acid silage may have disturbed kidney functioning. The inclusion of 3 ounces of pulverized limestone in the ration during the last weeks of the experiment gave some evidence of beneficial effect. In view of this experience, the feeding of pulverized limestone with acid silage is advised. It is not expensive, can do no harm, and it may avoid serious "off-feed" cases and possible injury of the cattle.

Legume silage preserved with molasses is not as palatable to dairy cattle as corn silage. Cows usually have to learn to like it. This may be accomplished by feeding small amounts at the start and making gradual increases. In the trials here reported, molasses silage was, in most cases, appreciably more palatable than phosphoric acid silage. Tests of amounts of molasses varying from 40 to 120 pounds per ton of green alfalfa indicated improved palatability as the molasses was increased. Satisfactory preservation of alfalfa was obtained with 40 pounds of molasses, but 80 pounds per ton appears to be about optimum. If the forage contains a lot of moisture and is not wilted, excessive seepage from the silo may take place. As this happens frequently, it appears inadvisable to use maximum amounts of molasses because of possible excessive losses. Trials with soybean silage indicate that 120 pounds molasses per ton of green forage is the optimum amount to use. One lot of silage preserved with 100 pounds of molasses was deficient in palatability. Eighteen pounds of 73% phosphoric acid per ton of green forage (alfalfa or soybeans) was the maximum amount used in the tests here reported. The palatability was fairly satisfactory at this rate, especially with alfalfa.

Alfalfa-molasses silage (80 pounds molasses per ton) and soybean-molasses silage (120 pounds molasses per ton) are of equal feeding value for milk production when fed in a ration with corn silage and hay. On account of the high cost of soybean silage, it is not advised except in an emergency when alfalfa or other legumes are not available. Ensilaging soybeans is usually preferable to curing for hay.

Legume silage, especially the first cutting of alfalfa, is highly satisfactory as supplementary feed for dairy cattle on short pastures in late summer or in drought periods. On most farms, especially in central Pennsylvania, this practice will result in saving considerable alfalfa that is usually lost because of unfavorable haying weather in June.

Fermentation studies of third cutting alfalfa reveal that quality of silage, based on lactic acid produced, improves as the amount of molasses for preservative is increased from 40 to 120 pounds per ton of green forage. As a general rule, alfalfa preserved with molasses produces more lactic acid than when it is preserved with phosphoric acid. In cases where alfalfa has a high initial sugar content, phosphoric-acid silage may be of as high quality as would result with molasses as preservative.

When legumes are cured into hay, a large part of the carotene and other nutrients may be lost through shattering of leaves and bleaching. Ensiling avoids practically all of this loss. After several months in storage, the carotene in legume silage tends to decrease appreciably. This decrease varies widely, but, in general, a good grade of legume silage in storage seven months will supply from 3 to 6 times as much carotene on a dry matter basis as alfalfa hay of good grade. Tests to date indicate that the carotene in legume-phosphoric acid silage tends to deteriorate rapidly after being in storage 5 to 6 months. The rate of decline is not nearly so pronounced in alfalfa-molasses silage, and several tests have revealed from three to five times as much carotene in alfalfa-molasses silage as in alfalfa-phosphoric acid silage after seven months of storage.

Title: The Fermentation of Alfalfa Silage Preserved with Molasses, Phosphoric Acid, Salt, and Silogerm.

Leaders: R. C. Malzahn, S. I. Bechdel, and R. W. Stone.

A series of small silos filled with the same cutting of alfalfa under six different treatments was studied with respect to the method of preservation. The treatments were (per ton of silage) 80 pounds molasses, 40 pounds molasses, 18 pounds phosphoric acid, 40 pounds molasses plus Silogerm, 30 pounds salt, and 30 pounds salt plus Silogerm. All silages underwent a typical lactic acid fermentation; the bacterial counts showed no correlation either with quality of the silage or treatment. The best silages from the standpoint of chemical analysis as well as feeding tests were obtained by use of 80 pounds of molasses and 18 pounds of acid per ton. The silages preserved with 40 pounds of molasses were slightly inferior to the first two and no significant difference could be found due to Silogerm treatment. Preservation with salt gave somewhat poor quality silages, likewise with no demonstrable difference due to Silogerm.

A comparison of the fermentation in the upper and lower levels of the series showed a contrasting chemical composition with evidence of less desirable changes taking place in the upper part of the silos. After periods of storage ranging from 6 to 10 months, irrespective of treatment, the higher levels had pH values that were generally above 4.2, a relatively low amount of reducing sugar and a high content of acetic acid. The lower levels in the same silos had pH values below 4.2, more reducing sugar, and averaged 31% more lactic acid. Feeding experiments indicated a more palatable and better quality silage from the lower than the higher portions of the silos.

RHODE ISLAND AGRICULTURAL EXPERIMENT STATION

Title: A Study of the Adaptability of Sudan Grass, Japanese Millet, Oats, Winter Rye, and Winter Wheat for Supplementary Pasture.

Leaders: T. E. Odland and T. R. Cox.

A study of different crops for use as supplementary pasture was completed and the results reported in a publication now in press. Permanent pastures usually decrease rapidly in the amount of grazing available after the flush season in June. The dairyman has to plan for some additional temporary pasture for the remainder of the season if he is to avoid barn feeding during this period. Barn feeding not only increases his costs of milk production, but usually results in less production as well. The dairyman wants to know what crops he can use to best advantage for supplementary pasture, when they should be planted to supply grazing for a particular period, and what feeding value they have.

In this test, winter rye, winter wheat, spring oats, Sudan grass, and Japanese millet were planted at various dates and the yields of pasturage determined. Chemical analyses were made on samples taken at the various cuttings for determinations of nutritional value. Usually 3 to 5 cuttings were made for each crop over periods ranging from 2 to 7 weeks. The results obtained over a 4-year period, 1938-1941, inclusive, can be summarized as follows:

Winter rye planted at 10-day intervals from August 10 to September 20 yielded pasturage from October 1 to 25 and from May 1 to June 10 of the following year. Winter wheat planted at the same dates yielded pasturage during the same period but made less growth. The seedings made on September 1 and 10 produced the most pasturage when both fall and spring yields were considered. Enough grazing was produced to carry two cows per acre for two weeks in the fall and five weeks in the spring.

Oats were seeded at three different times from April 15 to May 5. The May 5 planting was ready for grazing about June 15. An acre of oats planted at this time would furnish enough grazing for three cows over a period of four weeks at the rate of yield obtained in these tests. The April dates of planting produced grazing at a time when normally it would not be needed. Sudan grass and millet

planted at 2-week intervals from May 20 to July 15 furnished grazing from July 15 to September 25, a season of the year when permanent pastures are usually short. The May plantings of Sudan grass were generally unsatisfactory. Sudan grass is a warm-weather crop and should not be planted until early June in this section of Rhode Island. Two acres of Sudan grass yielded enough grazing, it was estimated, to support five cows over a 7-week period.

Sudan grass planted on a well-firmed seedbed produced better stands and considerably higher yield than when planted on a loosely prepared seedbed.

Determinations of prussic acid in the Sudan grass showed only small amounts of this and not enough to cause any harm to grazing animals.

Japanese millet supplied, on an average, a little more pasturage than did the Sudan grass over similar periods of time.

The chemical analyses showed all crops to be satisfactory in composition of feed nutrients.

Title: A Comparison of Different Crops for Grass Silage.

Leaders: T. E. Odland, T. R. Cox, and C. H. Moran.

A 3-year study of the value of different crops for grass silage was concluded and the results summarized in a publication now available. (A Comparison of Different Crops for Grass Silage by the Use of Mason Jars as Miniature Silos. T. E. Odland, T. R. Cox, and J. B. Smith. Jour. Amer. Soc. Agron. 33: 304-313. 1941). Winter rye, Sudan grass, Japanese millet, timothy, red clover, alfalfa, soybeans, as well as various mixtures of these, were used for making silage. Molasses and phosphoric acid were compared as preservatives in different amounts. All crops made satisfactory silage when harvested at the right stage of maturity and were otherwise in good condition. Two-quart mason jars made very satisfactory miniature silos for this study, the silage produced being very similar in all respects to silage from the same crops made in large farm silos. This experiment suggests a method of handling any surplus that might become available if more supplementary pasture crops were grown than were needed in a favorable season.

Title: Studies of the Behavior of Agrostis tenuis
(Colonial Bent) as Influenced by Environmental
Factors.

Leaders: Irene H. Stuckey and B. E. Gilbert.

The seasonal development of grass roots which has been followed since 1938 has been continued using colonial bent (Agrostis tenuis) Sibth) alone. Seeds were planted in September 1940 and measurements have been made of number and length of the new roots on these seedlings at intervals. Adventitious roots were produced almost continuously from four to six weeks after germination throughout the winter. The numbers of these roots increased until the maximum was reached in May. New roots developed through June but many became brown and wiry without growing more than two inches. Only mature roots were found during July, August, and September. These months and October were exceptionally dry for Rhode Island, which probably accounts for the absence of new roots in any quantity until October 20. By November 14 as many as 40 to 60 unbranched roots were found on a single large plant. At this time very few lateral rootlets were found but by November 30, new roots with lateral rootlets were encountered much more frequently than unbranched roots. Disintegrating old roots were found in May and again in late November.

Anatomical studies of the crowns of colonial bent plants collected at intervals throughout the winter and spring indicate that the roots are initiated in progressive circles outward from the base. The base becomes heavily lignified with age. The root initials were less frequent in May and June than earlier in the spring.

VERMONT AGRICULTURAL EXPERIMENT STATION

Title: Relative Value of TVA Phosphates on Pastures and
Meadows.

Leader: A. R. Midgley.

All permanent pastures suffered from an unusual drouth last spring and summer. Because of this, very little differences were obtained among the different fertilizer treatments. Most of the TVA phosphates, especially potassium metaphosphate and potassium-calcium metaphosphate, are so finely ground that it is almost impossible to apply them broadcast to pastures.

They readily blow away and on high phosphate fixing soils, their fine division favors such intimate contact with the soil, that fixation is increased. This is especially true where the fertilizer is worked into the soil previous to seeding. Under such circumstances the pelleted forms seem to be much better, especially where the B podzol horizon is predominant in the soil.

Title: Fertilization of pasture and meadow land.

Leader: A. R. Midgley.

A station bulletin has just been finished covering experimental data on this subject. Four out of 5 fields showed that the early spring application of complete fertilizers was superior to late fall. This was true whether the nitrogen used in the fertilizer was urea, cyanamid, or nitrate. The latter form was much better with the spring applications. Some fertilizer may be lost by run-off if applied too late in the fall on rolling land. If the soil freezes and becomes impervious before the surface applied fertilizer gets into the soil, the loss may be quite high. Leaching losses of nitrogen are also a factor, especially on the lighter soil types.

Title: Pasture Seeding Mixtures.

Leader: A. R. Midgley.

A number of plantings of zigzag clover were made on permanent hay and pasture lands. Due to the severe drought soon after planting, a poor stand was obtained on most fields. A large number of plantings of birdsfoot trefoil are to be made this spring under different soil and pasture conditions.

Title: Effect of Minor Elements on Growth of Native Clover in Pastures.

Leader: A. R. Midgley.

An application of borax, 30 pounds per acre, has given some response on pastures, especially where clover is predominant. This is especially true where lime has been recently applied.

Sulphur has also been beneficial on some pastures that are known to be rather low in this element. The amount of sulphur in the air at five locations within the state are being determined. It is known that the air is an important source of sulphur for soils and some interesting differences have already been obtained.

WEST VIRGINIA AGRICULTURAL EXPERIMENT STATION

Title: Pasture Fertilization Studies.

Leaders: F. W. Schaller, G. G. Pohlman, R. M. Smith,
H. O. Henderson, and R. A. Ackerman.

Small Plot Experiments. Clipped plots on the Dekalb silt loam at Morgantown which have received no treatment since 1932 still show the effect of lime and fertilizer and annual changes are very small. In March 1941 some of these plots were given additional applications of lime and fertilizer. Despite subnormal rainfall from February to May, inclusive, annual yields were somewhat higher and the percentage of white clover increased from 2 to 8% in June to 15 to 25% by September. On this same area, 24 plots which had previously been in a nitrogen study were differentially treated with lime, fertilizer, and seed. Some of the plots were also disked. The vegetation which was present showed a marked response to the fertilizer treatment but there was little evidence that the seed mixture used had any influence on the stand. The low spring rainfall and the vigorous competition afforded by the high percentage of *Danthonia* and weeds did not give the grass and legume seedlings a chance to become established.

The plots at Spencer on the Monongahela silt loam, which were refertilized in the fall of 1939, came back very vigorously during May and June of this year. Wild white clover came in abundantly and Kentucky bluegrass also appeared to be increasing. However, after the middle of July, when common lespedeza and broomsedge began to make their growth, the wild white clover and Kentucky bluegrass began to disappear. When botanical estimates were made in September there was found to be from 1 to 5% Kentucky bluegrass and 1 to 2% wild white clover. On the other hand, there was 10 to 20% common lespedeza and 50 to 60% broomsedge. From the data on this area over a 7-year period, it is evident that even with liming and fertilization Kentucky bluegrass and wild white clover have not been able to make any permanent increase against the competition of common lespedeza and broomsedge which flourish in the hot months of July and August.

The plots on the Upshur clay loam at Spencer which were also refertilized in the fall of 1939 show some increase in yield but very little improvement in the type of species present. In the seven years that this experiment has been carried on, Kentucky bluegrass has only increased from 1 to

8% as a result of lime and fertilizer. Although white clover has fluctuated from year to year, it is back to about 2%. It is believed that such an area, which is so low in productivity and has such a small percentage of desirable species to begin with, requires more than surface applications of lime and fertilizer to economically establish the pasture.

In the fall of 1940 three areas were treated to determine the rate and frequency of fertilizer application. Due to severe dry weather the plots at Lewisburg on limestone soil gave very little increase in yields during 1941. The yields were 1,553 pounds per acre for all treated plots as compared to 1,347 pounds per acre for the check plots. The white clover has almost entirely disappeared from all of the plots. On the Monongahela silt loam at Milton, where rainfall was not deficient, the increase in yields was high and white clover came in abundantly. The check plots gave an average yield of 1,128 pounds per acre. The plots which received lime and superphosphate gave yields of 1,594, 2,102, 2,506, and 2,758 pounds per acre for the 200, 400, 800, and 1,200 pound applications, respectively. The plots which received lime and 100 pounds of superphosphate in 1939 and 1940 gave a yield of 1,638 pounds per acre. Lime and superphosphate when used alone gave increases, the yields being 1,437 and 1,562 pounds, respectively. There was a small response from potash. The percentage of white clover was increased from a trace on the check plots to 8, 24, 32, and 30% on the plots which received lime and 200, 400, 800, and 1,200 pounds of superphosphate, respectively. The plots on a slightly calcareous shale at Wardensville have as yet shown no consistent increase in yields. There has been a small increase in white clover on a few plots.

Grazing Experiment. The grazing experiment with Ayrshire heifers on Monongahela silt loam soil at Wardensville continued to show large increases in carrying capacity of the fertilized plots in 1941. The check plots produced 63 pasture days per acre as compared to 116, 117, and 129 on the P-2L, P-K-2L, and N-P-K-2L plots, respectively. The percentage increase in total digestible nutrients from the lime and fertilizer treatments was 49, 58, and 62%, respectively, for the P-2L, P-K-2L, and N-P-K-2L plots.

The correlation of yields of total digestible nutrients as measured by the three clipping methods and by grazing was quite favorable this year. The yields of total digestible nutrients from the fertilized plots, when based on 100 for the grazing method, were 84, 86, and 73, respectively, for

the permanent plots, relocated plots, and the difference method plots. On the check plots these values were 136, 138, and 102 for the three treatments.

This experiment is to be discontinued since the lease on the land has expired. It will be written up for publication in the near future.

Title: Pasture Management Studies.

Leaders: F. W. Schaller, G. G. Pohlman, R. M. Smith, H. O. Henderson, and R. A. Ackerman.

The Kentucky bluegrass-white clover height of cutting experiment at Morgantown continues to show a high response from both superphosphate and muriate of potash. Regardless of strain of white clover or fertilizer treatment, the plots cut twice a year gave higher yields than those given frequent clippings. There was no significant effect on yield between the different strains of white clover.

Despite refertilization of these plots in the fall of 1939, and favorable rainfall in both 1940 and 1941, the white clover began to go out in 1940 and by the end of 1941 had almost entirely disappeared on all plots.

Title: Supplementary Pastures for West Virginia Livestock.

Leaders: F. W. Schaller, G. G. Pohlman, R. M. Smith, H. O. Henderson, and R. A. Ackerman.

No report. Experiment completed and will be written up for publication.

Title: The Effect of Contour Pasture Furrows on the Conservation of Soil and Water.

Leaders: F. W. Schaller, G. G. Pohlman, R. M. Smith, H. O. Henderson, and R. A. Ackerman.

Studies were made of vegetative pattern on a number of old furrows. These showed generally a greater density of vegetation in the bottom of the furrow than at any other place. The density was lowest on the berm, there being no clover and often considerable Canada bluegrass, indicating drier conditions than elsewhere in the pasture. The results have been written up for publication in VI of the Proceedings of the Soil Science Society of America.

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